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THE

GLOBE PREPARED FOR MAN;

A

GUIDE TO GEOLOGY.

BY THE AUTHOR OF "THE OBSERVING EYE, OR LETTERS ON NATURAL HISTORY,"
"THE PASSOVER FEASTS," ETC.

"Of old hast thou laid the foundation of the Earth."—Psalm cii., 25.
"He hath founded it upon the Seas, and established it upon the Floods."—Psalm xxiv., 2.
"The dry land of the world is little else than the bottoms of seas and lakes."—De La Beche.

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A GUIDE TO GEOLOGY.

BIBLIOTHECA · BO[illegible]ANA ·

A VOLCANO IN A STATE OF ERUPTION.

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PREFACE.

The discoveries made in Natural History by the study of Geology, excited a few years ago much alarm in the public mind, lest they should lead to statements at variance with the revealed account of the Creation.

But as the theories of imaginative minds have been made to yield to solid information, collected by the observation of excellent and learned men, this alarm has subsided. And the more the science has been pursued, upon the principle of a close investigation of facts, the more completely has it been found to harmonize with the Bible statements of the character and works of God; whilst at the same time, Geologists are free to own that it explains the cause of features in the outward works of Creation, unnoticed by the Word of Revelation, which dwells chiefly upon the moral and spiritual condition of man as he stands in connection with his Maker.

Geology "teems with endless examples of economy, order, and design." Its study is calculated to confirm our assurance in the existence of one supreme Creator—to exalt our convictions of the immensity of His wisdom, and of His all sustaining Providence. It excites attention to the objects around us, and exercises every faculty of the mind—reason, memory, imagination; and "though we cannot put our fossils to the question, it is something to be so aroused as to be able to put questions to ourselves."

The following sketch of this interesting study was originally prepared in the form of notes, for the instruction of a learner, whilst examining a small cabinet of fossils. In collecting information for the purpose the most esteemed authors were read, and wherever their ideas or words suited the object of the compiler they were unsparingly adopted; in consequence of which, the first scanty remarks were soon amplified into the work now prepared for the use of young people.

The chief authors consulted have been Lyell, Mantell, Buckland, Hugh Miller, Bakewell, De la Beche, Richardson, and Ansted.

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the only work they possessed that treated of the nature of earthy substances;* but as their book gave little account of the qualities of mixed soils, it was sometime before they discovered that many limestones and chalks give rise to a white earth, because they hold no iron in their substances—that flint is usually brown, from containing sufficient iron to yield a darkened hue—and that some sandy and clayey soils are red, from holding a good deal of iron in a rusty state, which tinges their substances with its own hue, just as rusty nails, left in water, give a red colour to the liquid.

Whilst rambling amongst the scenery of the country, their curiosity was again aroused on observing the stiff and sticky nature of some grounds, and the light and sandy qualities of others. They were surprised at observing that the farmer, in some districts, found it needful even to leave stones upon his fields, to prevent the vegetable mould and its crops from being drifted away by high winds. No allusion, however, being made in their book to this varied condition of the soils, they were under the necessity of leaving the subject for future study.

The changing aspect of the land, from plains to hills and from hills to dales, was a source of continual interest and enjoyment to the travellers. In some parts of Lincolnshire and Cambridgeshire, they had found the country almost as flat as a pond; the only rise and fall in the road, for miles together, having arisen from an ascent and descent over the arch of a bridge. In most parts of Norfolk, Suffolk, and Essex the ground had been gently varied by swelling undulations. In Kent, the hills had risen into bolder sweeps, quite lofty enough to astonish an aged Suffolk coachman, who, having to drive his mistress to Dover, had silently guided his horses up and down the steep Kentish hills, until gaining the summit of a long ascent (from whence he could see the view stretching out into the far distance), he drew up his steeds, placed his whip by his side, and gazing over the wide landscape of hill and dale, exclaimed with astonishment,—"World without end; Amen and Amen!" In Devonshire, the hills presented a lofty and beautiful aspect. As the eye followed the various boundaries of the fields hanging on their sides, they looked like the divisions on a map, and the houses at their feet dwindled into the size of mere dots. The hills of South Wales they found still more lofty, and were told they frequently contain rich stores of coal and iron. In Scotland and North Wales, in Westmorland and Cumberland, the tops of the majestic mountains were seen towering so high, that the clouds often swept round their heads in fine rolling masses, and as they slowly passed by, dropt their watery treasures into the crevices of the rocky earths, that composed the body of the mountain. These waters, sinking into the depths of the ground, again rose up in the valleys, and ran off in rivulets, carrying freshness to the green herbage, and gladness to man and beast.

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* Philip's Mineralogy.

Many mountains are formed of blue slates, others of limestone, or of enormous masses of sand, cemented together into hard strong layers. Other mountains are chiefly composed of vast piles of pebbles, and of broken pieces of rock firmly fixed together in beds of clay or lime, so as to form one hard mass, just as bricks thrown into a bed of mortar would, when dried, make one solid lump.* Other mountains, that lift up their heads in bold sharp points, have been formed by streams of red-hot earths or stony liquids; once as white with heat, as the molten† metal prepared in the glass-maker's furnace, for the workman's use.

A thoughtful person, looking upon these huge mountains, is ever ready to wonder from whence the multitude of their materials came, and by what powerful means they were thrown up into regions so lofty, that no man can dwell there, and only the wild birds of the air can visit the tops of their high ragged rocks. On these points our travelling party felt themselves perplexingly ignorant, and, as the learned book they possessed threw no light upon such subjects, the eye was the only inlet to knowledge of which they could avail themselves. With much interest they regarded the broken faces of the high mountains—the rivulets that leapt down their huge sides from rock to rock—and the wide and deep hollows which divide them many of which they remarked were filled with beautiful lakes of water. They saw that the surfaces of most of the rocks, from exposure to the action of the air, wind, and rain, had fallen into a soft and crumbling state, and beheld their fragments continually rolling down the steep descents into the waters below. They could also see the traces of many a wintry storm, on the faces of large masses of rock;—the expanding power of water, when in the act of freezing in their stony crevices, having shivered, split open, and rent them asunder, and thus added to the spoils that fell down the mountain sides. They beheld, rolling on through many of the valleys, rivers formed by the meeting together of numberless rivulets, which, in their onward way, looked at a distance like so many waving lines of silver thread. Their waters, fretting and foaming in their rapid course, drove before them collected masses of rock, sand, mud, and pebbles; and, frequently tearing down the river banks, added to their treasures the trunks and branches of trees, reeds, snail shells, the bones of birds and beasts, and whatever came within reach of their turbulent eddies. At length, rushing into the hollow of a lake, the whole river fell headlong into its large and placid sheet of water. The heaviest pieces of rock and pebbles sunk quickly to the bottom, whilst the muddier and lighter portions gently descended in cloudy masses through the deep waters. Substances thus poured into deep water, form, on reaching its bed, layers of mud and shingle—the force of the currents in the stream often driving them miles forward. On these beds of mud and shingle, caddis worms and animalculæ soon find a home, whilst pike, trout, and other fresh water fish, play their gambols above, until death overtaking them, their bones also become mingled with the various settlements below. As fresh supplies of soil are poured in by the rolling rivers, especially in the winter seasons, new deposits are quickly formed, which cover the former layers; and thus, layer upon layer is ever accumulating at the bottom of lakes. So vast is the quantity of mud and silt brought down by many mountain rivers, that small lakes have been entirely filled by their sediments. Several such instances are to be seen in Switzerland. The foaming torrent of the muddy Rhone has cast so much rock, mud, and sand, into the lake of Geneva, that a wide marshy plain, full seven miles long, is formed at the end by which the river enters the lake. Nearly two miles of this marshy land is known to have been made within the last eight hundred years, since a small Roman town, now a mile and a half away from its waters, formerly stood close to the side of the lake.

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* Rocks formed of these broken fragments, fixed in a bed of mud, are called breccias; when the pieces are sharp at their edges, they are termed conglomerates; when rounded, they are often called plumb-pudding stones.

† Molten, a red-hot liquid state.

The waters of a lake seldom overflow the banks, there is usually an outlet at the lower end, that forms a river, large enough to carry off the superfluous quantity. Some rivers however speed on their course for hundreds of miles without passing through any lakes, and finally discharge their waters into the bosom of the ocean. The mud and silt they have brought down is there sorted and settled; the heaviest and coarsest portions fall first, whilst the finest and lightest are borne by currents out to sea, and descend by slow degrees upon the floor of the great ocean. The amount of sediment held in the waters of many rivers is quite astonishing. A few bushes or stems of trees laid across the bed of a swift rolling stream, will often in a very short time, collect around them mud and sand sufficient to form a small island. When the silt brought down to the mouth of a river meets with no ocean current to drive it onwards, new land is constantly forming on the coast. This new land is called a delta. A delta is generally a low tract of ground, and is liable to be swept away by storms, by high tides, and by deluges of the rivers' fresh water overflowing it. Still in many places, new solid ground is actually gained. In the northern part of the Gulf of Trieste, and on the eastern side of Italy, land for the length of nearly one hundred miles, and from two to twenty miles in breadth, has been added to the coast by the muddy soils brought by the rivers Po and Addige from the Alps and Appenines, causing many towns described by the Romans in former days as harbours on the sea-shore, to be now standing many miles inland.*

The different mouths of the great river Ganges in

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* Mise or Misna Collis was said by the Roman writer Pomponius, to be nearly an Island, and this place is now far inland. In 895 Notre Dame Disporti was a harbour, and is now a league from the shore. Psalmodi was an island in 815, and is now two leagues from the sea. Several old lines of towns of sea-marks are at present far from the sea-coast. The town of Tignauc built on the sea-shore as late as 1737, is now a mile remote from it.
" *Lyell's Elements*, 207 *and* 258."

India, form a vast breadth of waters, extending with the strips of land that lie between them, to a width of more than two hundred miles. Into this delta of the Ganges, the river rushes down loaded with the muddy spoils of the Himmalaya mountains, which are the highest in the world. New beds of mud are constantly added to the sea-coasts by these deposits, some of which beds are eighty and ninety miles in length, and when they remain stationary, soon abound with shrubs, reeds, and long grass. Many large islands formed by the mud of the Ganges, are also dotted about in its delta; and when covered with forests of low wood, they become the hiding places for thousands of crocodiles, tigers, buffalos, and other wild beasts, whose bones as the creatures die, sink into the mud of the delta.

The river Mississippi runs through the continent of North America for three thousand miles. In its journey it passes through several lakes, yet its stream brings down to the ocean such masses of trees, sand, mud, and stones, that a tract of land is formed at the river's mouth, extending fifty miles into the sea. The muddy stream of the river Amazon in South America, can be traced three hundred miles under the waters of the sea, making as it were by the force of its own current, a channel for itself amidst the ocean waves.

Rivers are great blessings to mankind; they afford an easy means of communication between distant places; they supply moisture to the air, and rich stores of water for our domestic, agricultural, and manufacturing purposes. They drain low marshy tracts, and greatly assist in clearing away decaying particles of matter. So various are the substances carried by river streams into the sea, that were the beds of our present oceans to be lifted up, we should behold strange treasures mingled together, in their widely extended layers of sand and mud. We should find the bones of all kinds of land animals, and the wood of trees from all countries buried amongst sea-weeds, beds of coral, sponges, shells, and skeletons of fishes, together with pieces of wrecked vessels, and shattered furniture. These substances are regularly laid in vast ranges or beds, just as different storms, currents, and eddies in the water have driven them forward over the bed of the sea, until they have finally settled upon its muddy shingly deposits; each layer having in its turn been the uppermost bed, so that if the bottom of the ocean were really to be lifted up, and our eyes were to behold its broken edges, we should find them matching our present sea-cliffs, which often display many different materials resting upon each other; such as beds of sand on gravel, gravel upon chalk, layers of hardened mud upon pebbles, and pebbles upon sand. Several qualities of sand may often be seen in banks by the road-side. At the top, vegetable mould generally lies, then perhaps layers of sand; below the sand may be a line of pebbles, or a thin stratum of stone, and under these substances sand again.

Should the question be asked, why have all these changes taken place? why have the mighty mountains been lifted up? who made a law that stones and mud should roll down their sides? who cut the channels for rivers; and hollows for oceans and lakes? Would not a well taught mind quickly reply, these things have come to pass according to the good pleasure of that Almighty Being, who stretched forth the heavens, and laid the foundations of the earth. An excellent answer this would be, but such an one, as the wisest of men never gave until taught it from the Bible. That holy book opens with rendering to the One Supreme God the glory of creation; but observe, it throws no light upon the modes by which the Lord God formed the rocky crusts of the globe. It is from the works of nature alone, that we gain any idea of the process by which they were completed. And that process points back to such vast periods of time, that we are compelled to believe; ages upon ages lie unrecorded between the end of the first verse, and the beginning of the second verse of Genesis. The object of the bible was not to teach man natural history, but his moral and spiritual relationships to his Maker; it therefore only takes up the history of creation at that crisis, when the top soil was suitably prepared for the abode of an intellectual creature: sublimely declaring that in six days, and by six words of command, the Lord God separated the land from the waters, caused lights to shine in the firmament, and created on the surface of the earth His favoured creature man, with the vegetable and animal tribes now in existence.

Read attentively the works of those six days, and you will see, that in them, no allusion is made to the mode of forming the solid frame-work of the globe. They entirely relate to the changes which took place upon its prepared outward surface. But should a laudable desire have been awakened in any mind, to know something of the modes by which the Lord our God made and arranged the solid parts of the earth, we can examine the open book of nature; its stony leaves we can handle, and upon them we must reflect. Every slab of marble, every pebble has some wondrous tale impressed upon its form. And as we learn its writing, we shall acquire much knowledge of its past history; whilst in discovering the materials of which it is composed, and its right situation in the rocky coverings of the globe, we at once enter upon a subject of deep and commanding interest.

This examination of the earth's crust, in its different stony layers, is termed Geology, from the two Greek words—*Ge*, earth, and *logos*, a word.

The study of Geology, that is, of the earth's formation, was exactly the knowledge our travellers longed to be acquainted with, and this desire was at length gratified by the kindness of their friends, who supplied them with books, from which the following short but simple history has been compiled.

Our next chapter will contain a short account of the elementary substances, of which the crust or surface of the globe is composed.

CHAPTER 2.

THE MINERALS* OF THE EARTH.

The Numbers inserted in the Page relate to Questions at the end of the Chapter.

(1) THE Earth is a vast collection of minute atoms, forming a ball of heavy matter, flattened at its poles something like an orange. It hangs in the air upon nothing, and spins round itself in twenty-four hours. (2) The centre, or middle part of the earth, is believed to be in a thick fluid state, because the flattened shape of the earth is the form that a thick fluid takes, when rolling round in the air. And just as the juicy centre of an orange is covered by two or three rinds, so around the fluid centre of the earth are many rocky layers of varying thicknesses, which are believed to form altogether (3) a depth of eight or ten miles. Yet, so large is our globe, that this depth of eight or ten miles, is not a thicker crust upon its surface, than a sheet of paper would be upon the surface of an orange.

What the fluid substance is that lies in the centre of the globe, is not exactly known, but it is believed to be a mass of red-hot metals, about as liquid as iron and silver, when, by intense heat, they are thinned down to the consistency of mud.

The idea of the globe's internal heat is favoured by the fact, that in various parts of the earth flames rise from cracks in the ground, and also out of the summits of mountains. These flames are generally accompanied by smoke, steam, and red-hot muds, that roll down the sides of the mountains like broad rivers of fire. And in many parts of the world, springs of water rise up sufficiently hot to break glass, and to boil eggs.

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* A mineral is a body without life and without organs; it does not grow by drawing nourishment into itself like animals and vegetables, but becomes larger by additions to its outside.

Another striking proof of the intense heat in the centre of the earth is, that the lower men descend under ground, the warmer they find the air and the rocks. Not that men have been able to go very far under ground; the deepest mines that have been sunk for the purpose of obtaining such ores as lead, silver, copper, and iron, do not exceed the depth of about one mile from the surface. If the workmen tried to go deeper, they would be suffocated from want of fresh air to breathe.

(4) The whole mass of this round world is composed of various substances, joined and mixed together. Each substance or body being simply a collection of minute and perfect little atoms of matter packed close to one another. (5) According to the nature of these atoms, bodies are found to possess different qualities; and according to the closeness or separation of the atoms, so substances assume the form of either a solid, a fluid, or a vapour. Water readily takes all three of these states. In winter, the atoms of heat moving in water fly off, when its other particles are drawn close together, and it becomes a solid. Solid water, or ice, however takes up more room than fluid water. Its disengaged heat is believed to unite with the air floating in its substance.

and thus to produce a powerful expansion. In milder weather, when the atoms of water are but slightly separated, it remains a fluid; and under great heat, when its atoms are widely removed from each other, it becomes a vapour.

To ascertain the nature of the different substances which form the world, men have examined its liquids, its hard rocks and crumbling earths. They have noticed the materials which form the red-hot muds poured out of volcanoes, the sands of the sea, and the trees and flowers of the field. And after many experiments, they have come to the conclusion, that the great Creator has been pleased to form the earth and all things that are upon it, out of a very few simple bodies, called elements; (6) each elementary body being composed of only one set or kind of atoms. Many of these elements appear to be metals, shining like quicksilver. Others are transparent elastic fluids or vapours, called gases. These gases or elastic fluids are so thin, we can no more behold them with the eye, than we can behold steam, after it has flown up and spread itself over the air of a whole room. These thin elastic gases, God has, however, been pleased to spread abroad in great quantities, and they are found not only to be very abundant, but also very powerful fluids; just as heat is very powerful when it burns the skin, although we never can see the thin fluid of heat that touches us. Oxygen gas is said to be so abundant as to compose nearly one-half of the globe. By the union of oxygen-gas with hydrogen-gas, the liquid of water is formed; and by the union of oxygen with nitrogen the air we breathe chiefly arises.

(7) These vaporous gases, and a few other elementary substances, form sixty-one distinct and separate bodies; which bodies by their after combinations, become the basis of all things we see and touch on earth.—its fluids, rocks, herbage, flowers, and animals.*

The modes are various by which these sixty-one simple substances are united. In some cases two or three are pressed together, and form one new substance. In other cases, a few are made to cohere or stick together, just as an iron needle strongly adheres to a magnet; others again are changed by heat into quite new masses; and others by mixing together, are entirely altered in their qualities and forms. For instance, chlorine-gas, mixed with hydrogen-gas, makes muriatic acid, and this acid mixed with soda makes salt.

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* The sixty-one distinct bodies at present known are classed, for the help of the memory, under the following heads:—

Five Gases or Vapours. Oxygen, Hydrogen, Nitrogen, Chlorine, and Fluorine.

One non Metallic Fluid. Bromine.

Seven non Metallic Solids. Sulphur, Phosphorus, Selenium, Iodine Boron, Carbon, and Silicon.

Three Metallic bases of the Alkalies (a word meaning salt and sour.) Potassium, Sodium, and Lithium.

Four Metallic bases of the Alkaline Earths. Calcium, Magnesium, Barium, Strontium.

Four Metallic bases of the Earths. Aluminum which is the base of all clays, Glucinum, Yttrium, Zirconium.

Thirty Metals, such as Silver, Copper, Lead, Iron. Besides these, are a few rare bodies only known to the chemist, which form the sixty-one substances. "*Ansted.*"

(8) The greater part of the sixty-one basis substances are found in small detached parcels; sixteen only being of importance in the formation of the earth itself, and of the atmosphere that surrounds it; and consequently they alone possess especial claim upon the attention of the Geologist. These 16 substances are:—[*]

Five Gases.	Oxygen. Hydrogen. Nitrogen. Chlorine. Fluorine.
Three non Metallic Solids	Carbon. Sulphur, Phosphorus.
Four Earths.	Silicum.[†] Aluminum.[‡] Calcium.[§] Magnesia.
Two Metals.	Iron. Manganese.
Two Alkalies.	Sodium. Potassium.

Nor should it surprise us that God has been pleased to fill the world with a variety of things, out of so small a number of simple bodies. Consider for a moment how many thousand words are formed from the twenty-six letters of the Alphabet, and that, by simply changing their places. What endless harmony is produced by the various blendings of the seven original sounds, as they play on the air. And to name a more homely comparison, every one knows the endless variety of puddings, cakes, and sweets, the confectioner makes from the six materials of flour, water, sugar, eggs, butter, and fruit; altering their appearances and flavour just according as he mixes them together. Again, we see every day the effects of the law of change impressed upon bodies. A sheep has no resemblance to grass or turnips; yet it is by feeding upon such vegetables, that the wool, flesh, and bones of a sheep continue to grow. Such thoughts may help us to comprehend the truth, that sixteen substances when joined and mixed together by the will of an all powerful Being, are quite sufficient to fill the world with variety and beauty.

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[*] *Richardson.* [†] Silex. [‡] Clay. [§] Lime.

When a chemist desires to learn the number of first elements in any one particular body, suppose we say in a piece of rock or stone, his first effort is to take it to pieces. This he can often effect by applying heat; for heat being a very thin and powerful fluid, drives its atoms between the parts of all bodies, and forces their minute molecules to part asunder. At other times a substance can be subjected to the influence of another body, which has the power to attract or to draw away one of its parts from the rest. Hundreds of common workmen in iron mines use this power of attraction, in order to obtain the iron that is hidden in the dark brown clay found in many hills. Passages of a mile or more in length, are often cut into the heart of these iron bound hills, on purpose to obtain the rich clay; and as soon as it is carried from the mines, it is thrown, with a mixture of lime and coals, into immensely large earthen boilers, made red-hot by fire. There the whole mass is quickly melted down, and when its particles are thus separated by heat, the lime instantly seizes hold of the clay, and rising with it to the top of the cauldron, leaves the pure iron below. A plug is next drawn from the bottom of the furnace, when the iron runs into narrow channels of sand, made by the workmen to receive it.*

Iron is of great use to man, being in its nature malleable, that is, capable of being hammered into thin plates; and ductile, or capable of being drawn out into thin wire. And it is worthy of remark, as a proof of the providing care of our Heavenly Father, that iron clay is seldom met with, without having lime and coal in its neighbourhood. Thus, as it were, providing means for its general use, under the exertion of man's industry.

Another mode by which chemists discover the nature of a substance is, by testing its qualities, just as, in a very simple way, a person might try the materials of which an artificial flower is made. If he suspect that part of the flower is made of wax, he has only to test it by holding it to the fire, and if it melt he will see that he was right. The parts made of paper will not melt, but they will easily rend. Other parts, may be tougher than paper; if he suspect these parts to be made of cotton or silk, he will try to unravel them. Thus, by the tests of fire, of tearing and unravelling, four articles might be discovered in the formation of the flower. A chemist, with his higher skill, can then take these materials, and by applying to them strong heat, acids, alkalies, and other mixtures, he is able to find out which of the sixty-one simple substances have been used in making the wax paper, cotton, and silk.

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* The run iron, when cold, is taken out of the sand in short bars, called pigs of iron.

When a chemist wishes to take a flint to pieces, he heats it, and throws it into water, which breaks the stone into powder; and then by acids, and means which we cannot now describe, he quite dissolves its substance; finally discovering that almost half the flint had been made of the snow white substance, silicon, and the other half of oxygen gas, united to a slight mixture of clay, water, and iron. Lime, clay, and magnesia, can be dissolved nearly in the same way as flint, each one proving to be snow white silvery metals, burnt into powdery earths, by a union with oxygen gas.

(9) The four earths—flint, clay, lime, and magnesia, with the (10) two metals of iron and manganese, are found all over the world. They make the hard rocks of the earth, and its soft soils, as well as form the chief ingredients of our bones; whilst iron and manganese colour almost every substance. The rest of the earths and metals are found only in particular places.

Having so far learnt the history of the materials which compose the earth, which is the province of mineralogy, it is time to turn to the subject of Geology, that is, to the history of the hard rocky coverings, that are wrapped around the surface of the globe. We shall find, as our knowledge grows, that some rocks have been formed by fire, and that others have been formed by muddy and sandy layers, deposited one over the other under water; (11) the whole series bearing the stamp of such marked changes in their formation, that the rocks can be easily separated into five great divisions.

(12) Most Geologists have placed in the first division the rocks made by fire, which have usually been called the Primary rocks; by others, the Hypogene (or underborn) rocks, because they have been made in the lower parts of the red-hot globe, and have been afterwards forced upwards. All volcanic rocks come under this head.

(13) The second division contains rocks made of muddy, sandy, and fragmentary deposits, that have been washed into the sea; pressed upon by vast piles of after made rocks, and partly crystalised by heat and other causes. These rocks are called the Transition series.

(14) The third division is called the Secondary rocks, which are composed of enormous layers of muddy lime, of different appearances, and in different states of hardness, intermixed with sand-stones, and clay rocks. The whole series mostly formed under the sea.

(15) The fourth division is called the Tertiary series of rocks. These rocks are softer formations of lime, mud, and sand, than the third division, and are chiefly found in vast hollows, that have once been lakes, alternately filled with salt and fresh waters.

(16) The fifth division is composed of the Drift and Alluvium deposits, which consist of huge fragments of rock rolled from various distances, and of gravel and soft pulverized earths, braided fine by water. Such are the soils upon which we live.

By examining the stony crusts of the earth, we are taught that enormous ranges of rocks have by slow degrees succeeded one another, each one having once been the uppermost bed of the ocean. Many of these rocks contain in their layers marvellous displays of sponges, corals, shells, trees, and animals, in a stony or fossil state, most of which animal and vegetable remains belong to thousands of species, now unknown. We shall find that prodigious heavings of the molten masses in the depths of the globe, and vast explosions in the interior of the earth, have at many intervals burst asunder the different layers of the outward rocks, squeezing and pressing them together, and in apparent wild disorder, tilting them up into mountain ranges; whilst at other times, tremendous forces from beneath have borne up vast portions of the crust of the earth, and then again sunk them down to the extent of whole continents, as large as all Europe, Asia, Africa, and America.

In our next chapter we shall consider the first division, which treats of the under-born rocks.

The study of Geology is of considerable advantage to general society. From the want of some knowledge on this subject, men have often spent large sums of money in searching for coal where no coal could ever be found. It helps the miner to search aright for iron, copper, gold, and silver. It assists the architect to choose the best building stone; and the pump-maker to dig aright for water. It excites a thirst for the study of natural history; and in all its details, Geology inspires reverence towards our Great Creator. It demonstrates the universal will of one presiding intelligent mind. It extends our thoughts into immensity; teaching us that the revolutions of nature have occupied immense periods of time; and lastly, it stands forward as an abiding witness of the marvellous wisdom and goodness of that Almighty Being, who from Eternity has formed all things, and still upholds the universe by the power of his own creative will.

QUESTIONS.

Of what shape is the Earth?	(1)
Of what is the centre of the Earth thought to consist?	(2)
What depth of rock is said to surround the Earth?	(3)
Of what is the Earth supposed to consist?	(4)
What are the three forms in which matter subsists on Earth?	(5)
What is meant by elementary substances?	(6)
How many distinct elemental bodies and gases form the basis of things we see and touch?	(7)
How many of the sixty-one simple substances are of importance in the formation of rocks?	(8)
How many earths compose the general crust of the Globe?	(9)
How many ores are found everywhere?	(10
Into how many divisions have Geologists divided the rocks?	(11)
Give the names of these divisions	(12), (13), (14), (15), (16

FIRST DIVISION.

THE HYPOGENE, OR UNDER-BORN ROCKS, FORMED BY FIRE, AND SOMETIMES CALLED THE PRIMARY ROCKS.

CHAPTER 3.

GRANITE.

Our Globe it was remarked in the last chapter, is believed to contain within its centre, a mass of red-hot liquid minerals, and to have its exterior covered with hard rocks to the depth of eight or ten miles. (1) The lowest of these rocks is a solid stony substance called *granite*; and from granite being met with wherever lofty mountains have been thrown up, it is supposed that its solid substance encircles the earth.

No broken pieces of other rock are found in granite,* neither does it contain any traces of fossil or organic bodies, such as shells, bones, or plants. These facts tend to prove that granite forms one grand stony pavement, floating upon the red-hot minerals that compose the interior ot the globe.

(2) Granite is formed of three hard substances, which can be easily separated into distinct portions the one from the other. (3) These three substances are called quartz,† felspar, and mica. They appear to be joined together by pressure, without any cement to unite them.

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*Except the volcanic rocks.

† Quartz or flinty earth.

The colours of granite are of various shades of red and grey. Its quartz gives it a whitish tint; its felspar which is generally the most abundant of the three minerals, is either of a red or grey hue; and its mica, which is white or black, imparts to it in the sun-light a shining glittering appearance.

Granite is well known as a building material; being frequently used in erecting stately edifices and noble columns. Waterloo Bridge in London, and the great Obelisks of Egypt, are formed of granite. And in some places it is used for gate-posts, on account of its hardness and durability.

The quartz, felspar, and mica of granite, are not simple substances; each one of them is formed by the union of several bodies, as you may see by the note below.* How these various substances came to be drawn together, so as to form in the interior of the earth, the three distinct bodies of quartz, felspar, and mica, is not known; neither is it known by what means the three stony bodies of quartz, felspar, and mica, when made, came to be laid together and pressed into one lump. The great fact we have before us is, that granite is formed of such materials; and that unto the One Creator belongs the glory of forming all things by the word of his power, according to the good pleasure of His will.

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*Quartz or flinty earth, is formed of the silvery elementary body called silica, of oxygen-gas, and water, with a very small quantity of aluminum or clay.

Felspar; of silex, alumine, lime, potash, and oxide of iron.

Mica; of silex, alumine, magnesia, oxide of iron, and water.

The reason of man however can perceive that each material in granite appears to have been once liquid with heat, and that whilst gradually cooling, each primitive atom has had time to arrange itself side by side with its adjoining atom, so as to form its own particular figure, according to a law which the Creator has impressed upon all earthly bodies ; even that each original body shall possess a decided shape of its own. This peculiarity of form is called its crystalisation ; flint or quartz takes a six-sided figure ; crystals of lime have five sides ; and fluor-spar four ; others fall into their appointed arrangements.*

The three substances in Granite, of quartz, felspar, and mica, bear the appearance of having been first separately crystalised by heat, and then pressed together under an immense weight. Red-hot liquid earths are, at the present day, occasionally vomited forth from openings in volcanic mountains. And we find, the instant these boiling earths come under the light pressure of our atmosphere, the steam and gases mixed in their stony fluids escape, and leave a cindery looking clinkered rock, full of holes, called *lava*. Granite, on the contrary, has no holes; it is one complete solid, dense mass; and is, therefore, supposed to have been formed in the depths of the globe, where no air acted upon it, and that, in its solid state, it was (4) driven up by intense volcanic explosions to the surface of the molten* metals, in which it was made. Granite appears to be a substance continually forming amongst the heated materials in the interior of our globe, and to have been forced up at many different times, and at far distant intervals in the world's chronology. (5) Newly formed granite is sometimes found piercing into the body of older granites, cracking, rending, and melting portions of the older mass, and by filling up the fissures or rents thus made, it leaves the body of the older rock penetrated with veins of new rock. Granite has, in a few cases, been found even to penetrate into slates and limestones laid upon it, as may be seen in Glen Tilt, in Scotland.

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*Crystalisation. All masses of matter have a constant tendency to approach each other, this is called the attraction of gravitation.

Crystalisation is a peculiar property by which the particles of bodies are arranged in regular forms : and arises from the slow and regular reunion of the particles of a solid body, which have been separated or rendered liquid by heat, or by a union with other liquids. During the quiet evaporation or cooling of the liquid in which the particles have been held, the separated atoms are drawn together by the force of mutual attraction, and being given time to arrange themselves into regular masses, each individual assumes its own peculiar form. In eight years, flint after being dissolved in water, has been known to deposit a quartz crystal at the bottom of the phial. This uniform figure is supposed to arise from magnetic attraction, each atom having a north-pole, which attracts the south-pole of its adjoining atom, thus producing a symmetrical arrangement, through which light often readily passes. When the crystalisation is not completed, a body is said to be amorphous, just as the walls of a house formed of bricks and mortar may be thrown down, and lie in a shapeless mass; the bricks we may compare to the atoms of a body, the mortar to the invisible binding law of attraction, and the polarity to the skill of the builder, who was arranging the bricks into a form.

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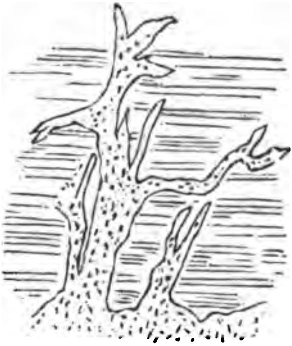
* Molten, a thick substance made liquid by heat.



New veins of Granite penetrating into Slate Rocks.

At other times, Granite has risen from beneath like a mighty wedge, bearing up on its huge sloping sides, rocks that had been long settled in flat layers upon it.* In our chapter on the Minerals of the Earth, we learnt that the present depth of rocks wrapped around the molten centre of the globe, is calculated at ten miles of thickness. This calculation is made by measuring the tilted up edges of the different strata of layers. If a long plank of wood

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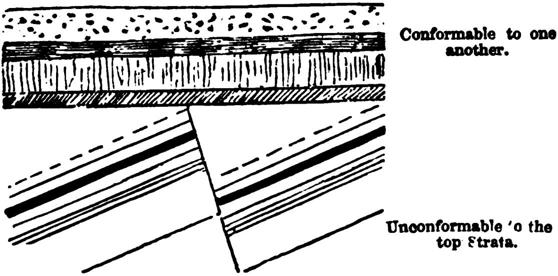
* NOTE.—Layers that lie flat or evenly upon one another, are termed conformable strata; when the conformable or flat layers rest upon *uptilted strata*, the flat layers rest unconformably upon the under rocks, which under ones are then called the unconformable strata.



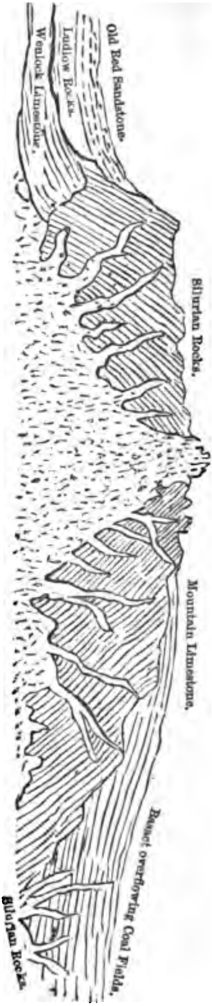
View of Stratification. Conformable Strata resting unconformably on uptilted Strata.

were lying flat on the ground, having fifty or one hundred planks of various thicknesses sunk beneath it in the earth, it would surpass the power of any one to guess what might be the depth of the whole pile. But should an iron bar be thrust under the lowest plank, and the whole range be tilted up, any one on going round to the raised end, could count the planks and measure their depth.

(6) In some parts of the world, Granite has performed the office of this iron bar, being itself forced upwards by volcanic agency, through all the rocks that rested upon it, and thus has carried up upon its sloping flanks, the broken edges of the disturbed rocks. By measuring the tilted-up edges of these exposed rocks, some idea has been formed of the general thickness of the different layers that

GRANITE TILTING UP THE ROCKS FORMED UPON IT.

Syenitic Trap elevating Silurian Rocks in North Wales.



The lines raised up by the centre Granite are Unconformable Rocks; the flat lines are Conformable, or, one over the other.

compose the crust of the earth; the Granite, or lowest one excepted, the bottom of which has never yet been found.

In the early part of the world's history, but few rocky layers had been formed; at a later period a vast amount had been deposited. Thus, by the number of rocks that lie on the sides of uplifted granite, we have a standard in the world's chronology, by which to judge of the age in which different ranges of mountains have been thrown up. In Cumberland, the Granite mountains must have risen quite early, as all the later rocks either fill up hollows in their masses, or rest at their bases; whilst on the giant sides of the mighty Alps, a variety of rocks, even gravel deposits are borne aloft in sloping directions. These deposits mark the late elevation of the Alpine mountains. (7) No one district of the earth, however, possesses a collection of all its rocky formations. (8) Most of the strata, or layers of rock, have been formed by the washing down of mud, sand, and pebbles, into the ocean, under whose waters they have been converted into stony masses. And, accordingly, as these sediments have been spread abroad, over greater or lesser distances of the ocean's floor, so one range of rock is found to extend for hundreds of miles, whilst others run only for short distances, or are not seen at all, never having been formed in that quarter.

(9) The violent lifting up of these stony beds out of the water, whenever the Creator has seen fit to convert them into dry land, has also caused vast

portions of their masses to be washed away, and others have slipped away during the shock of earthquakes; leaving as it were, rock heaped upon rock in confusion. But in the midst of what at first sight appears in mountain scenery to be nothing but a mass of disorder, there is yet a presiding arrangement to be discovered. No under rock is found resting upon a later formed one; as for instance, let four rocks be named A, B, C, D. A and D may meet face to face, having lost B, C, from between them; but A, the first made body, will never be found on the top of D, the last made body: each will be found in its right relative situation.

Granite is pierced throughout its masses by fine cracks or veins, that run in long lines, and often cross one another. (10) These veins are usually filled with various ores*, such as copper, iron, silver, gold, bismuth, wolfrain, but most abundantly with tin. (11) Some earthy minerals are also found in granite, such as the emerald and topaz. Beds of white statuary marble (which sparkles like loaf-sugar, and of which our best mantle-pieces are often made), are occasionally seen in granite, as well as enormous masses of white-quartz, or clear flinty earth. Much of this quartz is found in Scotland, there forming even considerable hills: it is generally crushed and broken, from the pressure of the mighty force, by which the granite, in which it lies, was upheaved.

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*Ore, a metal mixed with some earth.

(12) The convulsive upheavings which have at different times rent the stony pavement of the globe, have frequently forced the granite to rise through every strata that rested upon it, and have sent it up in lofty points, towering far above its overlying rocks, just as a sheet of blue pasteboard, covered by a pile of white papers, may have its blue edges pushed up through all the papers, by the forcing pressure of a blunt iron instrument passing through them from beneath. Had the first granitic coatings of our planet been left in the lower parts of the earth, loaded with the weight or overlying rocks, no eye of man could have seen, and no hand of man could have touched the rich metals they contain. But their masses, borne up, by vast and terrific explosions from beneath, are now placed within our reach, their ores are brought to the surface of the globe, and by the heavings and commotions that have taken place during their repeated elevations, the various rocks at first settled as flat plains of sand and mud over the granite, have also been turned into broken surfaces, by which changes the earth has been beautified with varied landscapes; supplied with channels and reservoirs for holding the waters of our springs, and rendered by the mixing of different soils, luxuriant in vegetation.

(13) When granite is extremely hard, its mountain peaks stand up like pointed pinnacles; (14) but when its felspar abounds with potash, the air soon dissolves the potash, and causes the outside of the rock to crumble to pieces, granite then assumes a heavy rounded

appearance,—this effect is strikingly seen in the Island of Jersey, in the English Channel.

QUESTIONS.

What is the name of the first rock in the Hypogene series?	(1)
How many stony substances form Granite?	(2)
What are their names?	(3)
What force drives granite to the surface of the Globe?	(4)
How is it known that granite has been formed at various times, and is now perhaps forming in the depths of the Earth?	(5)
By what means is the depths of rocks calculated?	(6)
Do the same rocks go all round the World?	(7)
Do rocks lie regularly one over another?	(8)
What has caused some rocks to slip away?	(9)
With what are veins in granite filled?	(10)
What besides ores are found in Granite?	(11)
What appearances do granite mountains present to the eye?	(12), (13), (14)

FIRST DIVISION.

THE METAMORPHIC, OR ALTERED HYPOGENE ROCKS, GNEISS, MICA SLATE, SCHISTS, CHLORITE, TALCOSE, & ROOFING SLATES.

CHAPTER 4.

PRIMARY, OR HYPOGENE ROCKS.

In a former chapter we considered the history of Granite, so far as it appears to relate its own tale. Formed in the depths of the hot globe, and thence by mighty heavings and volcanic eruptions driven to the surface, this rock, th[illegible]erald of the Earth's coming glory, appears to have proudly risen in vast and ponderous masses above the waters of the ocean. Its mountain-peaks and far extending plains glowing with tremendous heat, surrounded by steam, and clothed in glittering majesty,* must at that period have claimed the world as its own. We have no evidence that any other rock,† neither vegetable nor animal, at that time existed: probably from pole to pole, and around the circle of the whole earth, granite, and granite alone, reigned in undisputed sovereignty, amidst a wild waste of waters.

The enormous pressure which forcibly sent the granite upwards, appears also to have rent its masses into (1) blocks of a rhomboidal shape.‡ This form is

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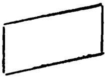
* Mica glitters in the light like stars of silver and gold

† Except perhaps the intrusion of fiery streams of volcanic mud.

‡ The action of electric fluid in the earth is also believed to have had an influence (in some unknown way) in forming granite into blocks of a rhomboidal figure.

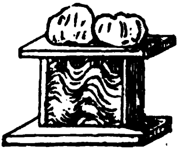


A Rhomboid.

found to pervade all granite mountains, (2) and the crashing effect of that force which broke it into rhomboids, probably gave rise to immense quantities of dust and fragments, which falling upon the surface of the waters, and mingling with the materials that afterwards crumbled off the sides of the risen granites, formed as they sank under the ocean, a new set of rocks called the metamorphic or changed crystaline rocks. The materials of these rocks being spread out in layers on the floor of the hot granite which lay under the waters, and being pressed upon by the heated masses of the early ocean, became a crystaline or baked stratified formation, devoid of all fossils.

(3) Some of the Metamorphic rocks appear also to have been sent up in masses from the centre of the globe, not in lumps like granite, but under circumstances that caused them to be spread out in layers. Two of those Metamorphic rocks are called (4) *Gneiss* and *Mica Slate.* They rest immediately upon the granite, and are formed of the same materials; only their quartz, mica, and felspar, are differently arranged. (5) In gneiss, the mica, quartz, and felspar, are not placed in separate patches, but the mica runs in plates between the felspar and quartz. It is this arrangement which gives the rock its slaty appearance. In most parts of the world gneiss covers the declivities or steep sides of granitic mountains, and is often bent and folded round them like drapery; as if the rock had been pressed when in a soft heated state. To

comprehend this form, lay several sheets of paper flat between two boards, and place a weight upon the top one ; then forcibly press two other boards one against each end of the sheets, and you will find that the paper will immediately rise into waving lines, like the the form assumed by gneiss. This sketch may lead you to understand the illustration.



Sheets of paper folded by pressure on top and sides.

Gneiss is met with in most parts of the world, and is rich in veins of metallic ores. In Sweden it is the principal rock of the land. It is seen in Scotland and in Ireland, but is scarce in England, being chiefly found in Cornwall.

(6) Mica slate is composed principally of quartz and of thin plates of mica, its felspar being in small quantities and seldom seen. The plates of mica are often as thin as fine paper, and generally run between the laminæ or leaves of the quartz ; this gives the rock a very slaty structure, which is not unfrequently waved and contorted. Mica slate is rich in most of the ores, and contains large masses of crystalised limestone and of quartz, as well as a beautifully coloured rock called *Serpentine*. In Cornwall, Serpentine is met with at the Land's End.

(7) The rest of the metamorphic or altered crystaline rocks consist of small scaly schists, (or a kind of slate that breaks off in small pieces but does not separate into long layers), greenish looking chlorite and talcose

slates, homblende slates, and the hard clay slates used for roofing houses. Roofing slates appear to have been formed of mud that was probably washed off high portions of granite exposed to the action of the air, frost, and rain. (8) These layers of mud must have settled in ranges upon the hot floor of the early ocean, where they became baked or hardened into a rough crystalised slate.

Vast must have been the depths of mud which produced our slate mountains, and long must have been the periods of years required for the settlement of its manifold layers. The very process of layer formation is in itself slow; only watch its process as it constantly goes forward to some extent at the bottom of every ditch. A good fall of rain brings over the sunken place a thin stream of mud, a second follows, then wintry floods bring layers of sand and gravel, whilst the leaves of Autumn deposit a stratum of vegetable matter; so that, were not our ditches occasionally cleared out, they would, after a long course of years become filled up by such collections.

The broken edges of a common slate display the fact, that its substance is formed of thin layers piled one over the other. In many instances each of these layers appears to have been laid down by itself, that is mechanically laid down as layers of mud in a ditch. (9) In others, deep deposits of fine muddy earth appear to have been separated into their finest leaves or plates by a chemical change, that is by an alteration in their quality, effected by the powers of electricity running through the mud; for chemists have proved by experiments upon a lump of moist clay, that when a stream of electric fluid, (such as forms the lightning in the Heavens) is forced through a mass of moist clay, it divides its substance into extremely thin plates or laminæ. This powerful electric fluid, as it runs through the clay, changing the situation of its atoms, and leaving them arranged in a rude laminated or paper-like structure, much resembling the leafy plates seen in our common slates.*

Thus two means appear to have been employed by the Great Creator in forming whole strata of slate rocks, many thousands feet in depth: first a mechanical driving of their muddy settlements into beds, and then a chemical movement, by electricity acting upon those settlements as they lay under the waves of an ocean; which rocks He has since been pleased to lift up from their watery beds, in the form of lofty mountains. Ranges of these slate rocks are seen in Wales, in Cumberland, and in every land on the face of the earth. And no common observer can look upon the edges of their slaty layers as they rest in sloping lines upon the edges of the great mountains, without being convinced, that violent earthquakes were the means employed to break up the flat beds or layers in which they were at first laid down, and of tilting them into the pointed peaked summits which present such beautiful features in our mountain scenery.

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*The electric fluid is also found by experiment so to act upon the metals that lie hidden in the body of the clay, as to separate them from the earthy substances with which they were blended,and collecting them together as simple minerals, causes them to fall into some crevice or cavity; by which means a mineral vein is deposited in the mass.

Who then can venture to calculate upon the time employed in the formation of vast ranges of our metamorphic rocks, all composed of different beds piled by millions one upon another. In such a labour the powers of man's arithmetic are set at nought; but with God, time is as nothing. He is from eternity, He holds the periods in His hands, and with Him thousands of years are but as a day.

We have next to consider the VOLCANIC ROCKS.

QUESTIONS.

What form do cleavages in Granite assume?	(1)
How were the Rocks now termed Metamorphic generally made?	(2), (3)
What are the names of the two rocks which rest on Granite?	(4)
How do Gneiss and Mica Slate differ from Granite?..	(5), (6)
What are the names of other Metamorphic Rocks? ..	(7)
How are the leaves or laminæ of Slates formed?	(8), (9)

FIRST DIVISION.

HYPOGENE, OR, TRAP ROCKS AND VOLCANOES.

CHAPTER 5.

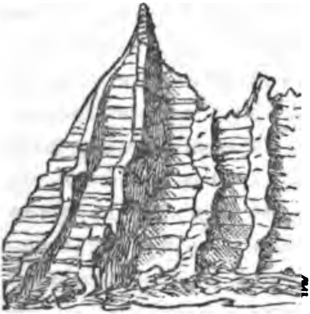
HISTORY OF TRAP.

The history of the Trap and Volcanic Rocks is not confined to any one particular period of the Earth's formation. Their origin is connected with vast movements in the lowest depths of the globe, which have poured their substances forth during every age of the world's existence in the form of red-hot muds and stony liquids. (2) These stony muds have usually risen out of vast rents in the surface of the globe, amidst noise, violence, and fearful overturnings of the crust of the Earth, which by internal movements has been elevated and depressed it to such degrees, that until the history of volcanic explosions was understood, no wisdom of man could account for the lifting up of ponderous masses of rock into mountain ranges of two, three, and five miles in height.

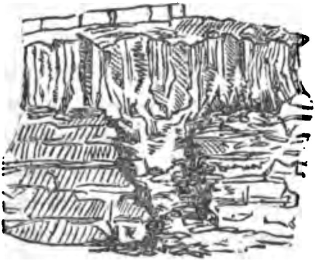
It is true that with God all things are possible, for He 'taketh up the isles as a very little thing,' and by a simple act of His will, He could have raised the mountains in one mass ; but as the Creator generally works by means, and the broken dislocated faces of mountain ranges point to some overwhelming power forcing them upward, man has been led to seek amongst the works of nature for the cause of these mighty upheavings. Now, of all the power of Earth we know of nothing so mighty in their overwhelming effects, as those produced by the explosions (3) of gas and steam. Whatever stands in the way of the expanding particles of these vapours, is either shivered to pieces or forced upwards. So powerful are these vapours in their action, that were they collected in sufficient quantity, they might blow the world to atoms. By many strong proofs we are therefore led to believe, that under the directing hand of God, explosions have repeatedly taken place amongst the gasses and fiery metals in the centre of the globe, which have frequently broken and tilted up the crust of the Earth; whilst at other times, the internal molten metals, undulating like the waves of the ocean, have gently and slowly borne up immense portions of the Earth's crust; whole continents by such means appearing to have been swelled up with as much ease as a boat rises on the surface of a billow, or a carpet, fastened at its corners, bulges up in the centre when the air rushes under it. Proofs exist, that elevations and depressions of such a kind, are still going on in the Earth. In Sweden, a large extent of coast, extending at least a thousand miles in length, which formerly lay under the waters of the Baltic Sea, has almost imperceptibly been lifted up from ten, to two hundred feet above the level of the water. Mud banks, with shells upon them, are from time to time laid dry; and by watching these lines of shells, and the marks that have been cut by Pilots on the banks, a great length of the Northern part of the Swedish coast is actually known to be now rising at the rate of from two to three feet in each hundred years; this elevation extends in some slight degree as far as to the shores of Russia. And should the same gentle liftings up continue, the upper part of the bed of the Baltic Sea must finally be laid dry. On the contrary, towards the south of Sweden, the land rather sinks, and for a space of six hundred miles on the eastern coast of Greenland, there are various signs and traditions, to prove the gradual sinking down of the land for the last four hundred years. Ancient buildings on rocky islands off the main land, are lowered under the waters. Experience has taught the Greenlander never to build his hut near the shore, and the Moravian Missionaries are often obliged to set up new poles inland, upon which to place their large boats; the old poles remaining beneath the waters, as silent witnesses of the change going on.

By the courses or lines in which mountain ranges run across the earth, we perceive that internal explosions have broken through the crust of the earth in several different directions. (4) In North and South America these disturbing powers have run chiefly from North to South, forming by their convulsive heavings the mighty Andes. In Europe and Asia they have run more from East to West, as seen in the Himalayan, Alpine, and Pyrenean mountains.

At the time these lofty mountains have been tilted up, red-hot (5) muds and stony liquids have been poured forth through enormous rents in the ground. Traces of these hot stony liquids are numerous in all rocks. They seem to have run over the beds of the seas, and to have forced themselves between the strata of all kinds of rocks; and by these violent intrusions, to have broken their arrangement. Sometimes the red-hot muds have run over the bed of the sea for hundreds of miles together, when their awful streams, on becoming cold, have been consolidated under the water, into dark close rocks, which now, under the name of Trap Rocks, stand out in our present hills and mountains, either in the shape of walls, dykes, and veins, or rest in over-lapping masses, hundreds of feet in thickness.



Dykes of Trap Rocks at the base of Etna.



Trap Vein rising up and overlaying Slate Rocks.

(6) These intrusive deposits are called Trap Rocks, from the Swedish word *trappa*, or *stair*, as they frequently lie one above the other (7) in stair-like terraces; which appearance seems to have arisen from one stream of the fiery fluid hardening, before its companion torrent overtook it.—*See the sketch*

Trap rocks are given several names, according to their materials. (8) Their most common terms are hornblende, basalt, green stone, obsidian, clinkstone, and porphyry.* The chief substance of which their masses are composed is felspar, mixed with some of the other earths, and a few metals.

The study of these igneous or fiery rocks, is peculiarly interesting to the Geologist, from the important part they have performed in altering the face of the Earth.

To the Agriculturist they are of peculiar benefit, as they possess a fine mixture of lime, clay, and sand, and the potash in their felspar causes them rapidly to decompose, and to form a rich vegetable mould.

Trap rocks assume several appearances. When their hot muds have been poured forth under water, they form hard and solid rock. Exposed to the air, they become porous, or, as was before remarked, full of holes, as can be seen in pumice stone. When cooled quickly, they often turn into a brittle or glassy substance. When cooled slowly, into a stony substance. And when still more gently, basalt takes the shape of a five or six sided column. This form arises from a tendency in the hot mass to form numerous little round portions, like cannon balls. When these balls touch one another, they become a little flattened at their sides, and as the mass goes on cooling, more balls are formed; until at last they press so heavily upon one another, that they shoot the mass out into a five-sided column. This figure is beautifully displayed in the Welsh mountain of Cader Idris, and at Fingal's Cave, in Scotland.

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* Porphyry is a paste of Trap Earth containing separate and distinct crystals of felspar.

Basaltic Columns, Cader Idris.

It is only within the last 60 or 70 years that the history of the trap rocks has been made a subject of study. At first, Geologists were greatly perplexed to account for their mixture amongst other rocks, and for the vast beds they had formed under the waters of the sea. Persevering enquiry is, however, generally crowned with success, and on carefully watching the operations of nature, as they are now passing, the Geologist is fully satisfied that the fiery muds, which now flow occasionally out of the mouths of two hundred and fifty volcanoes, in different parts of the world, cool down into substances somewhat resembling the old trap rocks. The account of these volcanoes will be given in our next chapter.

QUESTIONS.

Under what form do volcanic rocks first appear?	(1)
Where do their substances come from?	(2)
What are the two most powerful and active agents that appear to have broken up and torn open the crust of the Earth?	(3)
What mountain ranges shew us, that internal explosions have torn open the crust of the Earth in lines?	(4)
What has usually been poured out at the time of volcanic explosions?	(5)
What are the old streams of hot muds called?	(6)
What appearances do trap rocks assume?	(5)
What names are given to trap rocks?	(8)

FIRST DIVISION.

HYPOGENE ROCKS.

CHAPTER 6.

VOLCANOES.

(1) A VOLCANO is an opening in the crust of the earth, out of which are cast forth fiery muds and stony liquids.

(2) In the present state of the world, the two hundred and fifty volcanoes, named in the preceding chapter, are occasionally thrown into action, but there are traces of three thousand that, in former times, played an active part in changing the face of the earth. The principal seats of the present eruptive fires are found in the East Indies, in the Andes of South America, and in the mountains of Etna, Vesuvius, and Hecla, in Europe.

(3) Before a volcanic eruption takes place, the earth trembles violently; terrific noises are heard, resembling peals of distant thunder, the rapid running of carriages, and sharp discharges of artillery. These awful sounds come rolling on from depths below, and are occasioned by the cracking and rending of the rocks, as the heated steam and vaporous gasses labour to force a passage by which to escape.

The convulsed ground reels to and fro like the billows of the sea; hills are shattered and thrown down, trees and houses fall in every direction, darkness often covers the land, birds fly astonished, animals run about with fear, and men, stricken by terror, feel a sensation of giddiness and sickness; even the waves of the sea are often tremendously lifted up. Sudden chasms open in the earth, occasionally a mile or more in extent, from which are poured forth tremendous volumes of steam, smoke, and flames, accompanied by various gases strongly scented with sulphur. Explosions become louder and louder, followed by showers of red-hot stones and sand, which are shot up with immense violence into the air. On falling down, these substances expand into light pumice and dense clouds of dust, which, accumulating around the crater or opening, quickly raise a hill. Torrents of mud, of boiling water, and of melted stony fluids called (4) *Lava,* next roll down the newly formed cindery hill. For the gases, confined in the lava, in struggling to escape, cause huge streams of the heavy red-hot liquid to flow over the edge of the crater, just as water boils over the edge of a vessel, when the steam from below forces it upward; and this overflowing lava, in cooling, binds the loose substances into one solid stony mass.

In 1759, part of the plain of Malpay, in Mexico, for the space of three or four miles in extent, rose up in one night like a mass of viscid fluid, in the shape of a cone or bladder, nearly one thousand seven hundred feet in height. Flames issued forth from its sides, and red-hot stones were thrown to prodigious heights. The softened surface of the heated earth, was seen by the illumination of volcanic fires, to swell up and down like an agitated sea; and a huge cone of dust and ashes was at length suddenly formed on the summit, full five hundred feet in height. This central cone of Jurollo still exists, and is almost constantly in a burning state. Such volcanic mountains afterwards act as nature's safety valves, or as vast chimnies, to carry off steam and vapour from the Earth's boiling materials.

The crater on the summit of Mount Vesuvius, in Italy, is three miles round. From this enormous opening, steam, red-hot stones, and dust, have been seen to rise ten thousand feet into the air, and in the memory of man, it was once known to shoot up a stem of fire two miles and a half wide, which finally spread itself out into a fine arch of brilliant light. The air for six miles round the mountain became warmed by this grand but terrific discharge of heated minerals.

Violent eruptions of dust and melted lava, on falling 1800 years ago from the same mountain, overwhelmed the towns of Pompeii and Herculaneum; and these cities were not again seen till workmen, in digging for a well in 1713, accidentally opened their way into a street of Herculaneum.

So suddenly were these places overwhelmed by the volcanic mud and dust which destroyed them, that many of their inhabitants had no time to escape, and their skeletons have been found in the covered streets, and in the houses and gardens. The dense masses of rock and dust that settled over these towns, so entirely excluded the air, that much of the furniture, and many of the ornaments of their former inhabitants have been preserved. The beams of the houses have undergone but little alteration, excepting that they are invested with a black crust. Linen, fishing nets, and even fruits, such as walnuts, almonds, and chesnuts, are still distinctly visible. And the very loaves, standing for sale on the counter of a baker, are found stamped with the letter of his name, though blackened with age.

About sixty years ago, Mount Hecla, in Iceland, threw out two streams of lava, that ran for the distance of forty and fifty miles. The streams were ten and fifteen miles wide, and one hundred feet in height. Moving lava does not sink at once, like water, to the level of the ground. The stony liquid usually begins to flow out of the crater about as thick as honey, and when its outer crust cools, it stiffens with sufficient force to stand up like a high solid wall, yet continues to move on as if pushed forward.

"In the Spring of 1852, a large mountain in the Sandwich Islands was presenting a beautiful and grand display of volcanic eruption. By accurate measurements, a column of glowing molten lava rose from the crater, five hundred feet in height, and one hundred feet across, presenting a sight that excited, even at a distance of forty miles, the most lively feelings of admiration and awe. In some places the lava was flowing down the mountain as a river, a mile in width; at other points it had filled up ravines, one, two, and three hundred feet in depth. It entered a forest, and the giant growth of centuries was cut down before it, like grass before the scythe; no obstacle arrested its descent to the sea. Mounds were covered over, vallies filled up, and the habitations of man consumed like flax in the furnace. The eruption began ten thousand feet above the level of the sea, about fifty miles from the bay of Hela; and if it succeed in reaching the ocean, having filled up the ravines, and inequalities of a very broken country, it will be one of the most extensive eruptious of modern times."*

Sometimes jets of red-hot dust and ashes are driven by the wind to great distances, and, as they fall, set fire to whole woods and villages. During an eruption of the volcanic mountain of Truxillo, in Mexico, in 1835, its falling ashes killed thousands of cattle. Deer and other wild animals ran into towns for protection, their bodies, in many instances, becoming one mass of scorched flesh. Birds, as well as animals, for twenty-four miles round, were suffocated in the depth of the ashes, and the neighbouring streams were strewed with dead fish.

(5) The molten mud and lava of the old trap rocks appear to have generally flowed out of volcanoes that opened under the waters of the ocean. Such an eruption took place a few years ago in the Mediterranean Sea. A ship sailing over its clear waters, was suddenly shaken by an earthquake, the crew of the ship perceived a broad column of smoke rise out of the waters sixty feet in height, followed by clouds of steam. In a short space of time an island rose, two hundred feet above the waves, composed of dust, ashes, and pumice

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* *Witness*, May 19, 1852.

stone. In the centre of the island, a large cavity was kept open by the steam and gaseous vapours, which continued for some time to throw out cinders and fluid lava. On the eruption ceasing, the waves washed away the lighter parts of the island, leaving a ridge of lava rocks, which are still found a short distance under the waves.

Graham Island, in the Mediterranean Sea.

Nearly a hundred years ago, an earthquake at Lisbon destroyed sixty thousand people in six minutes. The greater number met with their death by one enormous wave that rose fifty feet in height, and dashed forward over the land, swallowing up boats, men, and houses. The shock of the Lisbon earthquake marks the volcanic chain of connection running under the earth. Its tremour was felt in England, all over Europe, and even in the West Indies. In Canada, the waters of the lakes were violently agitated. And near Morocco, in Africa, the earth opened in one vast chasm, that swallowed up a town containing ten thousand persons.

An affecting account has been left by Father Kircher, of a dreadful earthquake which took place in Calabria, in 1638, to which we shall slightly allude. Intending to visit the city of Euphœmia, Kircher, with a few friends, left Sicily in a boat; the weather proved unfavourable, and though his party often put to sea, they were for several days driven back. This merciful check in their desire to proceed, proved in the end the means of saving their lives.

Wearied at length by their long delay, Kircher and his friends resolved to prosecute their voyage. And he thus adds,—"Although the waters seemed more than usually agitated, we ventured forward. The sea wore at the time a very unusual appearance, those who have seen a lake in a violent shower of rain, covered all over with bubbles, may conceive some idea of its agitations. My surprise was increased by the calmness and serenity of the weather, for there was not a breeze or a cloud, which might be supposed to put all nature thus into motion. I therefore warned my companions that an earthquake was approaching, and, making for the shore, we landed at Tropedea, happy and thankful at having escaped the threatening dangers of the sea. But our triumphs at land were of short duration, for we had scarcely arrived in that city, when our ears were stunned with a horrid sound, resembling that of an infinite number of chariots driven fiercely forward—the wheels rattling, and the thongs cracking. A most dreadful earthquake ensued, so that the whole tract upon which we stood vibrated like the scale of a wavering balance. This motion, however, soon grew more violent, and being no longer able to keep my legs, I was thrown prostrate upon the ground. In the mean time, the universal ruin around me redoubled my amazement. The crash of falling houses, the tottering of towers, and the groans of the dying, all contributed to raise my terror and despair. On every side I saw nothing but a scene of ruin and danger threatening wherever I should fly. I commended myself to God, as my last great refuge. Finding that I remained unhurt amidst the general concussion, I resolved to venture for safety, and running as fast as I could, reached the shore, but almost terrified out of my reason. I did not search long before I found the boat in which I had landed, and my companions also, whose terrors were even greater than my own."

Pursuing their voyage, they came at length within sight of the city of Euphœmia, and beheld the mountain of Strombolo, at eighty miles distance, vomiting forth flames in an unusual manner. On landing, their attention was quickly turned from more remote to nearer danger.

"The rumbling sound of an approaching earthquake again alarmed us—it every moment seemed to grow louder, and to approach nearer. The place on which we stood now began to shake most dreadfully, so that, being unable to stand, my companions and I caught hold of whatever shrub grew next to us. Again turning my eyes towards the city, I could see only a frightful dark cloud, that seemed to rest upon the place, This the more surprised us, as the weather was very serene. We waited, therefore, till the cloud passed away, then, turning to look for the city, it was totally gone. Wonderful to tell, nothing but a dismal and putrid lake was seen where it once stood. We looked about to find some one that could tell us of its sad catastrophe, but could see no person; all was become a melancholy solitude—a scene of hideous desolation. Thus proceeding pensively along, in search of some human being that could give us a little information, at length we saw a boy sitting by the shore, and appearing stupified with terror. Of him, therefore, we enquired concerning the fall of the city, but he could not be prevailed upon to give us an answer. We entreated him with every expression of tenderness and pity to tell us, but his senses were quite wrapt up in the contemplation of the danger he had escaped. We offered him food, but he seemed to loathe the sight. We still persisted in our offices of kindness, but he only pointed to the place of the city, like one out of his senses, and then running into the woods, was never heard of after. Such was the fate of the city of Euphœmia; and as we continued our melancholy course along the shore, the whole coast, for the space of two hundred miles, presented nothing but the remains of cities, and of men, scattered without a habitation over the fields."

When we read of such awful effects produced by earthquakes and volcanic explosions, we can but admire the wisdom of our Heavenly Father, in finishing the foundations of the Earth before man was created. Bound to his fellow creatures by strong ties of affection and sympathy, man's life, amid the terrors of those stormy times in which "the mountains were brought forth," would have been one constant scene of agonizing suspense and danger; whilst the uncertainty of all things around him would have destroyed his energies in preparing for the future. With the lower creatures it is not so. They live without thought, and it appears by their relics in the rocks, that tribe after tribe reigned in sovereign authority upon the Earth, until about six thousand years ago, when man being created, was made the lordly but responsible tenant of this finished Earth; whose rocks bear the marks of having been for countless ages under the preparing hand of God.

QUESTIONS.

What is a volcano? .... (1)
How many volcanoes are now in occasional action? .... (2)
What is heard and felt before a volcano bursts forth?...... (3)
What is the hot stony muds called when cooled or hardened in the air? .... (4)
Where do the volcanic rocks appear to have opened, whilst our present dry lands were being arranged?........... ... (5)
What difference does it make, whether volcanic mud is poured out in the air or under water? See Chap. 5, page 43.

SECOND DIVISION.

CHAPTER 7.

GENERAL REMARKS UPON THE TRANSITION ROCKS.

TRANSITION Rocks, or (1) rocks changed from a crystaline to a softer state, succeeded the hypogene series. At the period of their formation, the condition of the Earth had undergone an important change. The heated masses of the early granites, which had risen above the waters, had been cooled by an exposure for ages to the influence of the air, rain, and frost. The central heat of the globe had also been checked in its ascent to the surface of the Earth, by the successive layers of metamorphic rocks accumulating round it, as well as by the numerous collections of muddy and stony substances poured forth during every volcanic eruption.*

(2) As repeated earthquakes tilted up and shivered the early rocky pavements of the globe, fresh supplies of mud and sandy materials were collected under the waters, by which a new set of rocks was arranged softer in their texture than the early crystaline, and, therefore, more suited for the growth of vegetables, and for the habitations of living creatures. This new

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* Volcanic muds are slow conductors of heat. From this cause, as soon as a crust has been formed upon the red-hot surface of a lava stream. a man can stand upon it without danger, although a stick thrust under the crust is instantly burnt. It requires ten years to cool a moderately deep bed of lava.

range of rocks is called the *Transition Series*, because, as we before remarked, they form a transit or change from the crystaline to the softer.

(3) Transition rocks rest unconformably upon the under rocks; that is, they do not lean against the sides of the older granites, gneiss, mica, and roofing slates, but fill up hollows on their surfaces, and rest in flat beds along the bases of the raised mountains; which arrangement is a clear proof, that they were formed after the hypogene, or first rocks, had been raised up.*

(4) Transition rocks consist of prodigious layers of sand and mud, of limestones, clays, and pebbly fragments, intermixed with trap rocks. Enormous collections of these materials were spread out in different patches over the floor of the ocean. And from the still continued heat of the earth and waters, many of the new rocks when their substances, such as lime, were fusible or easily melted, rapidly crystalised into marbles; of which, the marbles of Italy, Devonshire, and Derbyshire are striking examples. Other sandy and muddy substances became cemented into stone, forming depths of rock, thousands of feet in thickness.

A vast proportion of the materials composing the Transition rocks, was probably thrown upon the face of the ocean during volcanic explosions. The amount of dust, ashes, and powder, thrown abroad at these stormy periods, exceeds our powers of calculation.

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* See the Sketch of Unconformable Rocks, in Note on page 27.

Even in the present age of the world, when volcanic eruptions are trifles compared to the scale of their former action, the masses of ruin they scatter abroad are truly wonderful. During an eruption in 1815, in the Island of Sumbawa,* the rumbling roar as of artillery was heard three hundred miles off. The inhabitants of Java, ignorant from whence the noises came, beheld with astonishment the sky overcast by the arrival of clouds of ashes, which, as they slowly sailed past, produced, during the whole of the day, a state of utter darkness, of so dense a nature, that the rays of the sun could nowhere penetrate its gloom. Showers of ashes fell the whole time, which broke the roofs of houses, and covered the streets and fields with dust and ashes.

The captain of an English man-of-war, sailing near Macao, a great distance from Sumbawa, remarks,—"complete darkness covered the face of day. I never saw anything to equal it in the darkest night; it was impossible to see the hand when held close to the eyes. The ashes fell fast all the night, and were so light and subtile, that, notwithstanding the precaution of spreading awnings fore and aft as much as possible, they pervaded every part of the ship. At six o'clock the next morning it continued as dark as ever, but began to clear about half-past seven; and about eight o'clock objects could be faintly observed on deck. From this time it began to clear very fast. The appearance of the ship, when day-light returned, was most singular; every part being covered with the fallen matter. It had the appearance of calcined pumice stone, nearly the colour of wood ashes; it lay in heaps of a foot in depth on many parts of the deck, and several tons weight of it must have been thrown overboard. Though it seemed a light dust when it fell, it was, when pressed down, of considerable weight—a pint measure of it weighing twelve ounces and three-quarters; and when mixed with water formed a tenacious mud, difficult to be washed off."

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* In the Indian Ocean.

This account may convey some faint idea of the mode in which, during the early ages of the world, vast accumulations of pulverized earths were continually gathering together at the bottom of the seas, accompanied also by torrents of mud, swept down into the waters from the shivered sides of the raised rocks.

(5) Many Transition rocks contain rich veins of lead, silver, iron, and copper ores. But their chief point of interest to the Geologist is the dawn of animal life, which first breaks forth to his delight amidst their stony layers. (6) Transition rocks are the most ancient records in the world. Upon them are stamped the natural history of its earliest inhabitants. (7) These records assure us that as soon as the Earth was prepared for the habitation of living creatures, it pleased the great Creator to fill the waters of the seas, and to cover the surface of the Earth with animated beings. Each one being fitted by its shape, and by the instinct

of its life, to enjoy the good things that had been prepared for it.

Strange and unknown forms meet the eye of the Geologist, in these early tablets. Yet, in pursuing his investigations, he finds no new arrangements of life, but an evidence that from the beginning, the same (8) four great divisions of life, now in existence, have been the type by which the Creator wrought.

(9) The lowest form of life is called the *Radiated*, and is distinguished by the soft bodies of its animals. Some of these animals are without nerve in their frames, but all are furnished with tentaculæ, or long thread-like arms around the mouth, by which they supply themselves with food, and occasionally move. Most of the Radiata are stationary, and frequently form, by secretions from the skin, cases of lime around their bodies. Such are corals and starfishes.

(10) The next division is called the *Articulated*, and is composed of creatures whose soft bodies are covered by rings of horn or lime; such are insects, crabs, and spiders.

(11) Another division is called the *Molluscous*, and includes soft bodied animals, which are frequently protected by shells formed over them.

(12) The highest division is termed the *Vertebrated*, and contains creatures possessing back bones, and masses of nervous matter, called the brain. In this division, reptiles, fishes, birds, beasts, and man are placed.

(13) Particular rules in these four systems have been

varied, to suit the alterations in the moisture or dryness of the Earth, in its heat and cold, and in the air and food that the soils of different rocks have supplied. But whilst these four marked characters of animal life have never been altered, it is a striking fact, that very few shells or animals, of any description, are cast as it were in the same mould or dye, for many fathoms deep in the rocks. Changes in the soil or climate, or in the rising or sinking of lands, are found for a time to have destroyed whole species; and if once the lost species are replaced by a kind in some degree varied, the lost ones are never more to be met with. It would appear that God has then, from some cause, seen it good to strike them out of His Creation, and to place on the new rocks not any new style of creatures, but in his own creative power, to have made such manifest alterations in the forms of the same families, as would better adapt them for the new condition of the globe prepared for them. Upwards of 22,000 such extinct forms have been discovered by Geologists in the rocks of our globe.*

(14) And it is by observing these altered forms in the fossils, or stony skeletons enclosed in the rocks, that

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		Species extinct.	*Species now living.*
RADIATED	Extinct Corals	2,528	1,810
	Starfishes, &c.	1,186	432
ARTICULATED	Crabs, Insects, &c	2,576	66,391
MOLLUSCOUS	Shells	14,000	11,262
VERTEBRATED	Fishes	1,461	8,000
	Reptiles	384	1,055
	Birds	148	7,000
	Mammalia	708	2,030

These numbers may not be perfectly accurate, as discoveries are perpetually being made, but they approach the truth.—BRONN.

Geologists are enabled to fix the chronology; that is, the right order of succession in which the stony crusts of the Earth have been deposited. Neither the make nor the colour of a stony layer affords any certain rule by which to judge of its age. The lowest, or earliest made rocks are usually the hardest, and the highest, or latest made, the softest; yet, as various circumstances produced many changes in this order, the Geologist is compelled to fix his data of the Earth's history by the character of the shells, fishes, reptiles, insects, and other animals he finds embedded in the Earth. And so marvellous is the succession of these fossils, rising from the lower divisions up to the higher, that the reflective mind is constrained to acknowledge their existence, proves the over-ruling selection of the same beneficent mind during all ages.

(15) Thus is Geology ever laying open to the thinking mind a series of wonders, by which the power and wisdom of the Creator is exquisitely displayed.

QUESTIONS.

What are Transition Rocks?	(1)
Of what materials were they chiefly formed?	(2), (4)
How do Transition Rocks rest upon the older series?	(3)
What do Transition Rocks contain in veins?	(5)
Of what are they the records?	(6)
What do the animals embedded in the Transition Rocks teach us?	(7)
Into how many divisions have naturalists divided the animal creation?	(8)
Name the four divisions	(9), (10), (11), (12)
What do we learn has been varied in the four divisions of animal life?	(13)
By what means does the geologist learn the order in which the rocks were made?	(14)
What is Geology ever laying open before the reflective mind?	(15)

SECOND DIVISION.

TRANSITION ROCKS.

CHAPTER 8.

THE CAMBRIAN GROUP OF SLATES.

THE Transition series opens with a range of slate rocks, that rest upon the metamorphic or altered crystaline group, and which are termed (1) the Cambrian slates, (2) from having been first examined in Wales. They are formed of sand, clay, and lime, are rather softer in their texture than the roofing slates, (3) and from the smooth state of the laminæ, or separate plates in these rocks, we gather that they were deposited under tranquil waters. These Cambrian slates are met with in all parts of the world. The Isle of Man is chiefly composed of them. They are found in Westmoreland, and abundantly in North Wales. When a hammer falls with a sharp blow upon the edges of the Cambrian slates they split open, (4) and occasionally display, to the great delight of the Geologist, the casts of a few stony fossils*, which are the earliest glimpses we obtain of the first inhabitants of the globe. And what are these early fossils? (5) They are impressions of sea weeds, of singularly twisted lines or markings, worked upon the surface of the rocky layers. Indents, that resemble the tracks made by long thin bodied, many-legged worms, such as are frequently seen at this day, on turning up large stones by the sea side. Several kinds of bivalve, or two lidded shells, are likewise met with, the heralds, as it were, of the countless tribes of molluscous or soft bodied animals, that have since swarmed upon the land and in the waters. The shells in the Cambrian slates chiefly belong to the family of molluscous animals, called the Terebratulæ; a kind of mollusk, very interesting to the Naturalist, because some of this family are amongst the few living creatures that have never been changed in their forms, since the dawn of animal life, down to present times. The body of a Terebratula has neither head nor feet, only a mouth and stomach, with

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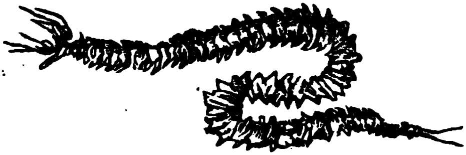
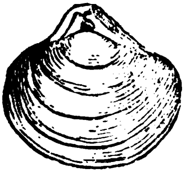
* Fossil—any animal, vegetable or shell that has been turned into stone, by resting in the earth.

Fossil, from the Latin, *fodio*, *to dig*—properly, anything dug out of the earth.



*Nereis Worm.**



common Terebratula.

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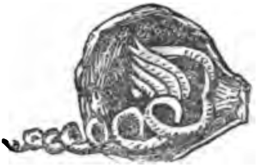
* It lays quietly on the sand, or in the sea: and often measures above eight feet in length. So great is the power of contraction in these worms, that a gentleman once put a very long one into a bottle of spirits of wine, when its rings were instantly drawn so close together, that the worm did not measure more than a foot.

a long corkscrew-like muscle, which it pushes out from between its two shells, in order to grasp hold of some firm object by which to steady itself. On this account the terebratula family are called the arm-footed, or Bracheopoda order.



Inside of Terebratula, with Arm Foot.

Two kinds of stony corals, built by thousands upon thousands of polype, or jelly-like worms,* have also been seen in the laminæ of the Cambrian slates. These two kinds of coral are found in the slates that form the top of Snowdon, the highest mountain in North Wales. At the period in which the Cambrian slates were forming under the waters, neither Great Britain nor any of the great continents of our world had been lifted up. The strata, or rocky layers, that now form our island and the present dry lands of the Earth, were at that time in the process of formation; (6) the waves of a vast ocean, therefore rolled over England, Scotland, and Ireland; and by the fossils found in these slates, we learn that the depths of the early waters varied just as our oceans do now. No coral animals can live and grow much below one hundred and fifty feet from the surface of the sea, because they require some light and warmth from the sun.† As corals, then, are enclosed in the slaty layers of the Cambrian group, we plainly see, that some parts of the olden seas in which they lived, could not have been very deep; whilst we find that other parts must have been of great depth, because some of the terebratula shells, buried in the Cambrian group of slates, belong to mollusks, which can only live very low down in the deep parts of the ocean.

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* See "Observing Eye," page 54.—Jarrold, 47, St. Paul's Churchyard.

† See "Observing Eye," page 56.

There is also another very important lesson we may gather from these slates. (7) The greater part of the material of which they are composed, are the muddy spoils washed from off dry lands. By this fact we are taught, that immensely large districts of the underneath or hard metamorphic rocks had been forcibly driven above the waters, *not* where land now is, but in the very parts of the globe at present covered by the waters of the Pacific and Atlantic Oceans.

"And where the Atlantic rolls,
Wide Continents have bloomed."

How long dry land continued to be raised above the waters in those parts of the globe, and at what time they were again submerged or sunk down, we know not.

The Lord Almighty lifts up one portion of the Earth's crust, and casts down another, when and where He pleases, just as the potter readily moulds his clay. All that we know is, that the greater part of the present solid rocks of the Earth, bear distinct marks of having been formed in layers under water, and that many of these rocks are composed of sands and muds, washed from off the surfaces of extensive dry lands. Immense collections, therefore, of sand and mud must have rolled into the seas, at that time covering the districts of our present Europe, Asia, Africa, and America; and as these materials became spread over the floors of the different oceans, they formed sheets of rock of various thicknesses, by which process the groundwork of our present lands was formed. And when, in the course of an immense series of ages, the Creator had sufficiently accomplished this work, the old dry grounds were submerged, and our lands were lifted up. Thus it seems, (8) that in forming the surface of the world, a perpetual and amazing work of change, by submersion and upheaving, has been carried on; during which periods, various animals, suited to the states of the earth and the waters, have been called into existence, and then again entirely removed, to make way for others still better adapted to meet further alterations.

Once more, by examining the Cambrian slates we learn, that the shores of those high lands which sent down their muddy spoils to form our rocks, fell by gentle slopes toward the seas that flowed around them; for in many instances, the rippled marks of gentle waves are stamped upon the face of the slaty layers, just as ripple marks are now left by the retreat of small waves, on the soft sea shore. These layers of mud and sand, impressed by the slight and passing movements of nature, and again covered over by other layers, must have been quickly hardened into stone, either by the effect of heat, or by water passing through them, charged with liquid lime, iron, or flint; the whole mass becoming finally pressed down, by the weight of new rocks forming over them.

Thus, by a slight attention to nature's own book, whose stony leaves are open before us, we obtain a glimpse of transactions that have taken place on this Earth, perhaps millions of ages ago, when all was young in the rocky coverings of the globe, and the wisdom of God, in the creation of living creatures, unfolding in its rising glories.

QUESTIONS.

What is the first range of rocks in the Transition series called? .... (1)
Why is the name of Cambrian given? .... (2)
What does the smooth state of the laminæ of the slates teach us? .... (3)
What does the blow of a hammer open to our view in the Cambrian slates? .... (4)
What variety of stony fossils? .... (5)
What covered England, and all the present dry lands of the world, at the time the Cambrian slates were formed? (6)
What other lesson do the Cambrian slates teach us?...... (7)
What do the changes in the situations of dry lands and water teach us? .... (8)

SECOND DIVISION.

CHAPTER 9.

GENERAL REMARKS UPON THE GRAU-WACKE GROUP.

THE Cambrian slates were deposited during a long succession of tranquil seasons, but after their completion stormy times came on. A grand series of volcanic eruptions followed, tilting up the rocks already deposited, and shivering to atoms vast portions of their masses. At repeated intervals, streams of red-hot trap burst through the ocean's floor, and ran over the bed of the sea, forming enormous ranges of rocks; many of whose beds (since lifted up) now form enormous basaltic masses in the Welsh hills. Cader Idris is, in some parts, almost composed of basaltic earth.

These outbursts of trap were attended by mighty and long-continued upheavings, which can be clearly traced in the confused piling up of the slate rocks throughout Europe. At that period, Professor Sedgwick has proved, that many of our British mountains, on the western side of the kingdom, were gradually lifted above the waters, since rocks of a later date, instead of sloping against the up-turned slates, are either settled at their bases, or the top of the slates are covered over by the later formation of the Old Red Sandstone.*

Long seasons of rest intervened between these terrific rendings and overturnings. And during these seasons of comparative quiet, the loosened fragments of rock, sunk into muddy pastes, of lime, clay, or sand, derived from the crushed relics of the older rocks, or the crumbled soils of elevated lands; and, accordingly, as currents in the water had driven these materials forward, or but slightly moved them, so their muddy layers became piled up by the millions, one over the other, or extended over the floor of the ancient oceans for hundreds of miles.

(1) To the rocks formed at this era, the Germans have given the name of *Grau-Wacke*, (2) or sand and fragments. The colour of the Grau-Wacke series is grey, varying from blueish to purple; and (3) most of its rocks present the appearance of having been formed in water, under violent commotion. (4) When the fragments in the muddy paste are very fine, the rock passes into a common slate, often glittering with mica. When the stony particles are larger, and so numerous that the earthy paste is little seen, then the rock resembles gritstone. Much of this gritstone is found in Derbyshire, Westmoreland, and other parts of England. When the fragments settled in the lime, or

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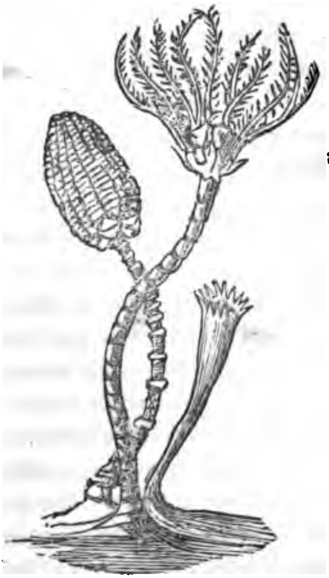
* We are indebted to Professor Sedgwick for the first clear account of this very ancient elevation of the slate rocks. His close examination of the slates in Westmoreland, having enabled him to trace the same formation in all parts of Europe.

clay, are large and separate, the rock is called a *Breccia;*—the sharp edged pieces, a Conglomerate—the round ones are often termed a plum-pudding stone.

(5) Each layer in the Grau-Wacke rocks was in its turn, the uppermost bed of the sea, (6) and upon the once soft surfaces of these layers we can trace the hand of the Creator introducing fresh races of animals. Eleven hundred species of fossil creatures, most of which are now extinct, have already been discovered in these rocks. The muddy beds, as well as the creatures they contain having become masses of hardened stone. This change from mud to rock, was produced by heat, by crystalisation, or by the chemical mixtures of iron, lime, or flint, percolating in a liquid state through their soft substances. The whole mass, as before remarked, being finally pressed down by the tremendous weight of new rocks settling over them.

Some of the Grau-Wacke rocks swarm with animal shapes most wonderful to behold. But the first surprise over, a cool examination of these strange looking creatures convinces the mind that no fresh types of form are to be seen, but simply a display of changes in the working out of the four great divisions of life described in page 60.

The shapes which look so strange to us, were no doubt the best adapted to suit the modes of life the creatures were then appointed to follow. Amongst these creatures, multitudes are to be seen called the (8) Encrinites, which like star fishes set on a pliable jointed stalk, could wave themselves to and fro in the waters, in search of the food they needed.



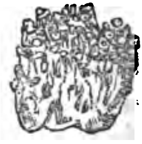
Encrinites.

(9) Not less than ninety-eight different kinds of corals, peopled by innumerable polype, or worm-like builders, rose also in vast ridges, in quantity without number, amid the shallower seas of this period. These living creatures appear to have risen like forests amidst the waters; ever casting forth their tens of thousands of tentaculæ or sensitive arms placed around their mouths.*

FOSSIL CORALS.

Cyathophyllum Turbinatum.

Caryophyllia Annularis.



Syringopora Geniculata.

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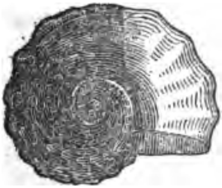
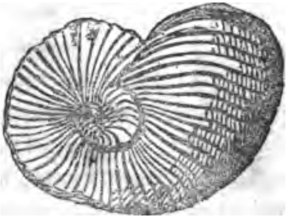
* See the account of these Encrinites in the "Observing Eye," page 115.

In the rocks of the Grau-Wacke formation, (10) one hundred and ninety-one sorts of two lidded or bivalve shells have been discovered. They are principally of the Brachiopoda order, or of those kinds of mollusca that fasten themselves to firm objects, by pushing out an arm, foot, or strong muscle from between their shells. The mollusks of one species of these shells called the Terebratula tribe were so numerous at this time, and of such large sizes, they might be called the Brachiopoda Lords of high degree. (11) Shells, answering the purpose of diving bells, light and beautiful in their construction, and fitted in the inside with air chambers, now appear to have floated for the first time in the waters of the ocean. These shells, called ammonites, could be made to ascend or descend through vast depths, just as their inhabitants desired either to bask in the light and warmth of the surface, or to dive to the bottom of the waters. They are termed the ammonite and nautilus families. About two hundred and fifty varieties of these shells have been met with



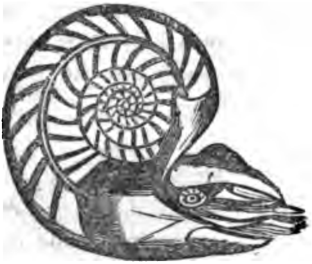
Ammonite.



Nautilus.

in our rocks, varying in size from that of a pin's head to three feet across.

The mollusks which inhabited them, when not wishing to float in the water, walked on their heads, carrying their shells on their backs, like snails; and when in a ravenous mood, the creatures thrust out parrot-like beaks, with which they attacked* their prey.



Tentacula and Beak.

Ammonite Shell, shewing the air chambers, the Siphuncle, with the Mollusk in front.

Orthocera Shell.

Other molluscous creatures having also horny beaks, with large eyes, and many arms around their mouths, had straight shells, very much in appearance resembling ammonites, unrolled. These shells, which are called the (12) Orthocera tribe, were divided into many air chambers, by means of shelly plates running across them. They were sometimes of great size, as much as three feet long; and if the supposition be true, that these straight shells were covered by a membraneous bag, or thick skin, the living creature belonging to such a shell must, on thrusting its head forward, have presented a most formidable appearance;

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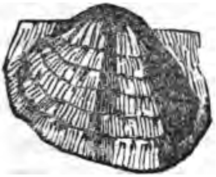
* See the history of these mollusks and their shells in 'Observing Eye,' Letter 37.

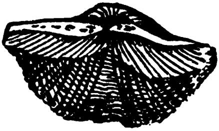
whilst its numerous arms, all covered with suckers for entrapping its prey, must have rendered it a fearful companion to many of the inhabitants of the Grau-Wacke waters.

The Orthoceras and Ammonites are now quite extinct. The nautilus families still remain in our seas, but are diminished both in their numbers, and sizes, from those of the ancient species.

(13) The Producta is a shell found in great abundance amidst the Grau-Wacke formations, but after the Mountain limestone was formed (which covers the Grau-Wacke rocks), this shell becomes scarce. (14) The Spirifer shell was also abundant, and continued to exist during the formation of two or three more sets of rocks, but after the settlement of the Lias limestones, this peculiar species of Spirifer is also lost sight of



Producta.



Spirifer.

(15) Sea pens,* of shapes quite extinct, existed by myriads in the Grau-Wacke seas; their forms, however, are handed down to our wondering sight, stamped upon the layers of clay and lime amongst which they

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* For a description of Sea pens see 'Observing Eye,' page 64.

lived. Five species of worms have left marks on the Grau-Wacke beds over which they crawled. Several kinds of Serpula* worms, such as now form twisted lime tubes upon old oyster shells, have left the stamp of their races upon these ancient muddy beds; many of which far exceeded in size the present living species

The living Sea Pen of our present Oceans.

Recent group of Serpula, with the worm raising its head out of the tube.

Other orders of creatures called (16) Trilobites, approaching in form to both insects and crabs, but not like either of them, appear in the higher Grau-Wacke rocks. They had crescent-shaped heads, hard coats on their bodies like those of a beetle, which were jointed and sometimes rolled up like a lobster's tail, or the armour of a woodlouse. They had eyes like a butterfly, adapted to look both round and above them; each eye containing not less than four hundred lenses, or small magnifying glasses, through each of which they could see the object that was opposite to it. These Trilobites passed through as many changes of form, in their growth from the egg, as our present crabs undergo.* They appear to have lived on the land, as well as in the waters. To have revelled by myriads upon the dry earth, and to have blackened the shallow waters; adhering together in vast clusters, trilobite over trilobite in the hollow parts of precipices, and on the flat muddy beds of the sea. Two hundred and fifty varieties of trilobites have already been discovered. From their numbers, and the large size of some of the species, they have been called the master existence of those early periods.†

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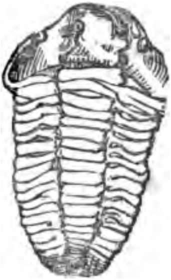
* See on Serpula in 'Observing Eye,' page 147.


Trilobite.

In our next chapter we shall examine the distinct kinds of rock which form this Grau-Wacke series.

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* See 'Observing Eye,' page 169.

† Trilobites derive their name from the three lobes into which their bodies are divided.

QUESTIONS.

What group of rocks follow the Cambrian slates?............ (1)
What does the name Grau-Wacke mean?...................... (2)
Did the Grau-Wacke rocks denote a quiet season on the Earth?.. (1), (3)
What are the different names given to the pastes of mud and sand of the Grau-Wacke series? .... (4)
What did each layer of the Grau-Wacke rocks once form? (5)
What is found on the once soft layers of each pile of mud? (6)
Are any of the Grau-Wacke animals like our own living species? .... (7)
Can you mention any of the animals found in the Grau-Wacke series?... (8), (9), (10), (11), (12), (13), (14), (15), (16)
What was the name of the animal, between the beetle and a crab? .... (16)

SECOND DIVISION.

GRAU-WACKE ROCKS.

CHAPTER 10.

CONSISTING OF THE SILURIAN ROCKS, AND THE OLD RED SANDSTONE OR DEVONIAN GROUP.

THE lowest set of rocks in the Grau-Wacke series is called (1) the Silurian range, because that part of Wales in which they abound, and where they have been the most examined, was formerly inhabited by the Silures; a brave tribe of ancient Britons from whom sprung the noble Caractacus.

(2) The Silurian range may be said to be almost without exception, composed of clay and siliceous sand, mixed often with mica, which seems to shew that its long series of crystaline slates,—micaceous sandstones, and quartz rocks, must have been principally formed out of materials washed into the sea by the breaking down and wearing away of granitic rocks. (3) The Silurian rocks contain groups of shells of all sizes and of all ages. Many of their finest edges are still quite perfect, which proves beyond a doubt, that they were never rolled in the waters. The mollusks which formed them, must have lived and died on the very beds in which their shells became imbedded under a slow and long continued settlement of mud. The lowest range of these Silurian rocks is called (4) the Llandeilo Flags. They received this name in consequence of having been

minutely examined by English geologists, in the neighbourhood of Llandeilo, in North Wales, where they are said to be one thousand two hundred feet in thickness. (5) The Llandeilo flags are formed of a dark limy mud, holding a good deal of mica in its substance. They contain shells and trilobites. (6) Above these flags is found a light yellow sandstone, called the Caradoc sandstone, which is two thousand five hundred feet thick, and contains many shells, corals, encrinites, and trilobites in its layers. Above the Caradoc sandstones lie two sets of Ludlow rocks, and one of Wenlock.

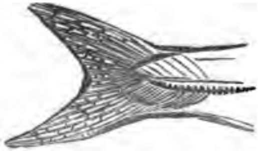
In the uppermost Ludlow rocks, there suddenly appears a higher order of beings than the radiated animals, the mollusks, or the articulated trilobites, of which we have read.(71) Fish, now, for the first time appear?—the lowest class of animals possessing a back bone and brain. Nor do these fish come before us few in number, but judging by their remains, the Creator had caused them to multiply fast, and to swarm in large shoals in the waters of the Silurian seas. The immense amount of their remains astonished those persons who first noticed them. Long and wide districts in the upper Ludlow rocks looked, as their layers were spread open, (8) like the burying grounds of all the fishes of that age.

One continuous range of matted bones, jaws, teeth, spines, scales, palated plates, and shagreen like prickles, lay all massed together,—converted into a substance of so deep and shining a jet colour, that the bed, when first discovered, conveyed the impression, says Sir R. Murchison, "that it enclosed a heap of pounded black beetles." And such are the remains of what seem to have been the first existing Vertebrata.

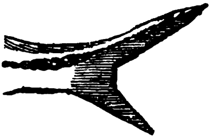
(9) The fish in the Ludlow rocks are very small, and not formed exactly like our present fish. (10) Indeed, out of two thousand different kinds of fossil fish, that have been discovered in the layers of various rocks, a very few exactly resemble the species that swim in our present seas. Not that the Almighty Creator made the first fishes more imperfectly than the latter ones, but He appears to have varied their forms, to suit the state of the waters in which they had to live.

(11) Very few early fishes possessed a skeleton of hard bones. Soft gristle chiefly supplied their place, (12) the hard bone being placed on the outside of their bodies, in the form of bony scales, which were highly coloured, and often polished or enamelled like teeth. These plates of bone covering their soft flesh, gave firmness to the whole body; and by this contrivance they were able to bear the pressure of deep and agitated waters, and it is thought to live in waters much hotter than horny scaled fishes can endure. The heads of many of these early fishes were also covered by finely enamelled bone, highly coloured and polished. They had sharp firmly-set teeth, capable of crushing corals and shells, upon which it is known they partly fed, from the pieces that are occasionally found in their insides.(13) The tails of the present fishes, possessing hard bones, are divided into two equal lobes, but the fishes that have soft internal gristle and bony scales, have the back

bone carried on to the end of the top lobe, which causes it to be much longer than the under lobe; this form still exists in living sturgeon, and is the prevailing one in all the early fishes embedded in the stony layers of the rocks. Dr. Buckland remarks,—"This form of tail enables the fish, whilst feeding upon sea weeds and dead animal remains, on the bed of the sea, to keep its body in an inclined position, with the head and mouth nearest to the bottom." Thus we find in all eras of the world, that an important provision has been made in every animal, to give a position of ease and activity to the head, during the operation of feeding.



Modern Fishes' Tail—the Herring.
Homocercal.



Ancient Fishes' Tail.
Heterocercal.

TILESTONES.

(14) After the upper Ludlow rocks had been formed, the Earth seems to have enjoyed a season of great quiet; during which time (15) sand was continually washed down from the high lands, and being ground into powder, finer even than that which we find on our present sea shores, deep ranges of delicate quartoze, or flinty sandstones were formed, to the depth in places of eight hundred feet, all gently deposited in the finest paper-like leaves. This formation is

called the *Tilestones*, amongst whose layers much pounded mica is spread. Tilestones are generally of a reddish or green hue. In Scotland, England, Germany, and Russia, a few species of fish, and several kinds of shells, have been found buried in the delicate leaves or laminæ of this rock, which is sometimes used as a building stone. In Wales, that is, in Carmarthenshire, Brecknockshire, and on the borders of Radnorshire, the tilestone deposit can be clearly seen. And on the sides of the mountainous ranges of those lands, they are often tilted up to an elevation of one thousand five hundred or one thousand six hundred feet.

OLD RED SANDSTONE, OR DEVONIAN GROUP.

Our short history of the Silurian rocks is now finished, and we have next to consider (16) the Old Red Sandstone, or, as it is sometimes called, the Devonian Group, which will complete the Grau-Wacke series.

(17) Storms, tempests, and terrific earthquakes, accompanied by deep hollow crashing sounds, must have ushered in this new arrangement of the Earth's crust, for the Old Red Sandstone group chiefly consists of the ruins of the lower rocks, piled together in such prodigious heaps, that (18) its depth is calculated to exceed twice the height of any one of our highest Scotch mountains. And whilst large portions of the Earth's thickened crust were thus rent and shattered by internal explosions, other movements raised up vast districts of land to the surface of the waters.

By such continued volcanic upheavings the floors of the seas were strewed with (19) an immense succession of small and huge boulders, consisting of the shivered fragments of trap rocks, granite, gneiss, mica slates, serpentines, limestones, and of the Silurian and Ludlow ranges. All these loosened boulders appear for ages to have been rolling backwards and forwards in the shallow waters that covered the raised lands, until every sharp edge and angle being rubbed off, they assumed the appearance of polished rounded pebbles. To this day, enormous quantities of such pebbles may be seen, formed out of quartz that will strike fire, and of porphyries so hard they will cut glass.

Long and violent must have been the rolling these broken fragments underwent, before they became by friction, one against the other, thus ground down and polished; and before the vast collections of pounded sand, crushed off the stony edges of the boulders, could have sunk into the crevices between the pebbles, and bound them together into solid masses of stone, (21) averaging ten thousand feet in depth. So much time does such a process demand, we are lost in astonishment at the ages required for the completion of the work! (20)

A serious question now arises, as to the manner in which this depth of Red Sandstone was formed. To allow of such heaps upon heaps of sea rocks ten thousand feet deep, to be piled up, must have demanded a great depth of waters, yet, to grind down the pebbles of this formation into smooth balls, a shallow state of the waters must have prevailed; since it is well known that all waves, currents, and eddies lose, in great depths, the power of rolling one body upon another. How then are we to account for the existence of the two facts before us? Piles of rocks requiring deep waters, at the same time that the pebbles, of which they are mostly composed, denote the existense of shallow waters. The only possible way by which we can solve this difficulty, is to look at the present works of nature; and by them we are taught, that the lifted up crust of the Earth must have been constantly, gradually, and slowly sinking down again—the lowest beds consolidating and sinking as the loosened boulders, just under the surface of the waters, kept forming new layers.

Almost every feature in the Old Red Sandstone formation points to the "footsteps of storms." Its layers bear the stamp of rising and falling lands. Its conglomerates,* and its red and yellow sandstones, denote terrible crashing commotions, whilst its trap rocks bespeak fire and noise. Short intervals of repose, however, are marked by the settlements of various layers of yellow marls, of clays, and blue limestones, all filled with animal remains. The whole again being subjected to confusion, violence, and change, through fresh volcanic explosions.

(23) The Old Red Sandstone, or Devonian group,

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* Conglomerate—broken pieces of rock cemented together in a muddy paste of lime, clay, or sand.

runs through great part of Scotland, and down the western side of England. It is found in Germany, in Russia, and in most parts of the globe, as yet examined by Geologists. The colours of this group are red, yellow, and blue. Its mixtures of fine and coarse materials give to its external appearances very different aspects, yet it is recognised in all parts of the world by the fossils it contains.

When the layers of the old red sandstone were forming, the world was no barren desert! Portions of wood, drifted from its ancient high lands, have been preserved in balls of clay, and they prove that its hills and dales were covered with plants of various kinds. Sea weeds and shells abounded, also crab-like animals; and numerous and large shoals of fish basked in the waters, then covering England, Scotland, and our present continents.*

Fossils are rarely met with in a perfect state in the red coloured sandstones.(23) Gravel and sands, formed by the rolling of broken rocks, are not the places amongst which animals abide; and such brittle substances as shells, falling amongst stones, are soon injured by rubbing together. Oxide of iron, which imparts its red hue to these rocks, has also a tendency to destroy all animal remains. But in the yellow clays, and blue limestones resting between the beds of this series, numerous fossils, chiefly of fish, have been discovered.

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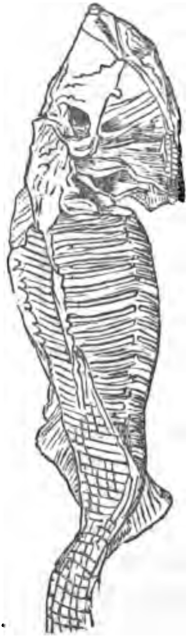
* The relics of these ancient fishes, found in the Orknies, might be carried away by the cart loads.—*Hugh Miller's Footsteps.*

Judging by the size of the head bones, and the impressions left of their bodies, (24) these fish must have varied from the dimensions of sprats, to that of fishes twenty-three feet in length; (25) many presenting shapes most peculiar, and covered with brilliantly enamelled square bony scales of great size. The heads of many of these ancient fishes were also covered with enamelled bones of great dimensions. Mr. Miller mentions having seen one of these head bones (found in the north of Scotland), that measured in width fifteen and a half inches, and when unbroken must have been twenty-three inches and a half in length. He adds, "Did the shield still exist in its original state, as a buckler of tough enamel crusted bone, it might be converted into a highland target, nearly broad enough to cover the ample chest of a Rob Roy, or Allan M'Aulay, and strong enough to dash aside the keenest broadsword."* Specimens from Russia have been seen of still larger size.

(26) Huge lobster-like looking creatures, full fourfeet in length have also been met with. Another



Cephalaspis Fish, of the Old Red Sandstone formation.

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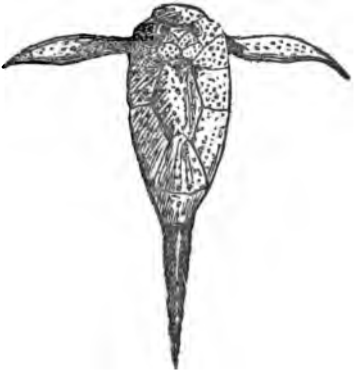
* Miller's "Footsteps of the Creator

race of most singular creatures, that by their existence seemed to have formed a link between the crab and fish families, likewise swarmed in the waters of the Old Red Sandstone oceans. These singular creatures have been given the name of Pterichthys, or the winged fish.



Pterichthys, the mouth side of the body covered with Plates, like the Tortoise.

The history of fossils is a study yet in its infancy, the subject having scarcely been noticed a hundred years ago. It is, therefore, not surprising that fresh discoveries should be frequently made, and that this remarkable fish, called the Pte–rich–thys, should only have been known within the last thirty years. It was first discovered by Mr. Hugh Miller, in the north of Scotland. That gentleman, from a boy, has been a close observer of the works of nature, and in his history of "The Old Red Sandstone Formation," describes in lively terms his first acquaintance with this winged fish. "I fain wish," he says, "that I ld communicate to the reader the feeling with ch I contemplated my first found specimen of this creature. The ball in which it was enclosed opened with a tough blow of the hammer; and there, on a ground of light coloured limestone, lay the effigy of a creature, fashioned apparently out of jet, with a body covered with plates, two powerful arms jointed at the shoulders, a head as entirely lost in the trunk as that of the ray, or the sunfish, and a long angular tail. My first formed idea regading it was, that I had discovered a connecting link between the tortoise and the fish, the body much resembling that of a small turtle; and why, I asked, if one formation gives us lizard fishes, may not another give us turtle ones?" Hugh Miller, unable to decide upon the true nature of his newly discovered specimen, at length sent it to be examined by the most learned Geologists, and they pronounced it to be an extinct animal, belonging to the tribe of fishes. The body of the creature was covered with a strong armour of bony plates, which grew in size at their edges like the plates of a tortoise; it had two arms, that only wanted feathers to make them look like wings, which stretched out from its head. Its tail seemed to serve either for a foot, or to steer by, and its whole body appeared as well adapted to pass through the air, as the water.—See the sketch in page 88

Hugh Miller, at first, thought that the arms by its head were paddles to assist it in swimming, but the learned French naturalist, Agassiz, assured him they were weapons of defence, "that usually lay close to the creature's body, but could be erected in moments of danger and alarm, like the present river bull head, which when attacked by an enemy, immediately as it feels the hook in its jaws, erects its two spines at nearly right angles with the plates of its head, as if to render itself as difficult of being swallowed as possible."

(87)Another creature, of the same kind of crab family as the Pterichthys, is found in the old red sandstone, and this latter creature nearly resembles the shape of a boy's kite. To obtain some idea of the varied treasures in this formation, let us listen to a ramble Mr. Hugh Miller enjoyed, one fine day in August, along the shores of the little bay of Cromarty, in the north of Scotland. His road lay by a grass walk to the side of a huge range of gneiss rock, called the Southern Sutors. The form of this rock reminded him of an enormous wedge of stone, which, driven up from below had, in its tremendous rise, lifted up against its sides all the later formed rocks. Leaving the side of this huge granite wedge, that stretched its back far out into the waves of the sea, he passed over the lower ground of the bay. The tide was low, and his path led him over the surfaces of many strata of rocks. First he walked over a line of the conglomerate system, next over a few beds of yellowish sandstone, then followed greyish limestones, afterwards beds of grey stratified clay rocks, separated by bands of micacious sandstone. Large boulders of stones, and a wide waste of shingle, covered many parts of the low grounds of the little bay, much of which was now laid bare by the retreat of the tide. In the middle of this tract of beach, stood a large table-like boulder, that Hugh Miller had often visited before,—"an uncouth looking mass," he tells us, "several tons in weight, with a flat upper surface like a table; and as a table, when engaged in collecting my specimens, I have often found occasion to employ it." Here he set to work carefully to break and to examine some of the boulders that lay thickly strewed around, and continues :—

* "The first nodule I laid open contained a dark looking mass, in which I could trace a few pointed bones and a few minute scales. The next abounded in nearly square finely enamelled scales, of a much larger size, and of more distinct characters. I wrought on with the eagerness of a discoverer, entering for the first time into an unknown land of wonders. Almost every fragment of clay, every splinter of sandstone, every limestone nodule, contained its fossils. Scales, spines, plates, bones, entire fish, but not one fossil of the Lias" (for which he was searching) "could I find, no ammonite, no belemnites, no gryphites, no shells of any kind. The vegetable impressions were entirely different, and not a single scale, plate, or remains of fish, could I see, like those of the newer formations. I had got into a different world, and among the remains of a different creation; but where could I find its proper place in the scale of the rocks? The beds of the little bay are encircled by thick accumulations of

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* The wording in this extract, from the book entitled 'The Old Red Sandstone,' by Hugh Miller, is slightly altered, in order to introduce simpler terms.

water-rolled stones, but I could not trace their relation to a single known rock I was struck, as I well might, by the utter strangeness of the forms; the oar-like arms of the Pterichthys; its tortoise-like plates; the strange buckler-looking head of another unknown creature,* which I supposed might possibly be the back of a small tortoise, though the knobs upon it reminded me rather of the skin of the shark; the polished scales and plates of one fish,† the spinned and scaled fins of another; and above all, the one-sided face of at least eight out of the ten or twelve varieties of fossils which the deposit contained, altogether excited and astonished me. Some time elapsed ere I learnt to distinguish the nicer differences of the various fragments of the formation; I found fragments of the winged fish on this first morning, but it was not till a year after this time that I really discovered its whole form. I was utterly at a loss to name, or even how to distinguish many of the specimens I collected Still, however, I saw enough to exhilirate and to interest; I wrought on, till the advancing tide came splashing over the nodules, and a powerful August sun had risen towards the middle sky; and were I to sum up all my happiest hours, the hour would not be forgotten in which I sat down on a rounded boulder of granite, by the edge of the sea, when the last bed was covered, and I spread out on the beach before me the spoils of the morning."

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* The Coccosteus.

† The Osteolepis

Fossil fragments of a similar description to those found by Hugh Miller, have also been met with in several inland districts of Scotland, as well as very largely in the old red sandstone formation in Russia.(28) And as every animal in this formation belonged to the sea, we have a striking proof afforded us, that the whole of Scotland and Russia, which are now laid dry, were once under the waters of the ocean.

The outline of these fossil animals is so perfectly stamped upon the stony layers, in which their bodies have been embedded, that no decay of their parts could have taken place, previously to their having been wrapped around in their muddy envelopes. They appear to have died suddenly, as nine out of ten of the winged fish are found with their sharp fins erected, as if in an attitude of fear and alarm. Sudden changes in the state of the water, arising, probably, from volcanic explosions at the bottom of the sea, might have destroyed them, and afterwards enclosed their bodies in a stream of hot muddy lime. Heat and sulphurous vapours instantly poison the inhabitants of the waters, and lime almost as rapidly. Some workmen engaged in building a bridge, having accidentally thrown a few baskets of lime into the river, the fish immediately rose to the surface, and were seen for some distance floating down the stream quite dead. Had the lime been in such abundance, that the bodies of these dead fish could have been enclosed in its mud, they would have been placed under the exact circumstances in which we now find the olden fishes in the bay of Cromarty.

The rocks of the old red sandstone formation, do not at present exist as one vast deep mass.(29) The intrusion of trap rocks, and the repeated upliftings and depressions of the earth's crust in later periods, have subjected them, as well as all other rocks, to the rush of mighty waters over their surfaces. On the upheaving of a tract of land, the retiring floods, rolling in terrific haste and with tremendous power down the sides of the rising grounds, have invariably torn away immense portions of the rocks, and cut valleys out of the softer layers; and thus carrying away masses of their soil into the present oceans, have frequently left the hard, underneath strata quite bare. This transporting and denuding power in water is peculiarly seen in the old red sandstone formation, which once covered whole counties in Scotland, South Wales, and in the south of England, but whose relics are now, in many instances, only to be seen perched high on the tops of lofty hills. At other times the old red sandstone is thrown up in heaps, so as to form ranges of mountainous hills. In Herefordshire, in Devonshire, and in other districts, the vast rushing of waters over the Old Red Sandstone group is clearly apparent.

The Mendip Hills in Somersetshire are believed to have been surrounded, and partly covered over by an immense depth of red sandstone, the whole of which, excepting in a few situations, has been carried away.

In all these changings and overturnings, we perceive that the Creator consulted the future good of his creatures, for by breaking up the harder rocks, and by mixing their soils, the earth has by degrees been made capable of bearing much fruit, and of supporting large families of the highest races of living creatures.

QUESTIONS.

What is the name of the lowest set of the Grau-Wacke rocks? (1)

Of what do the Silurian rocks consist? (2)

What do the Silurian rocks contain? (3)

What are the first rocks in the Silurian range? (4)

Of what are they formed? (5)

What is above the Llandeilo flags? (6)

What suddenly appears in the Ludlow rocks? (7)

What did these first beds of fishes look like? (8)

Do the fishes in the Ludlow rocks resemble those of the present day? (9)

How many thousand fossil fish have been discovered? (10)

What kind of bones had most of the early fishes? (11)

Where, then, was the hard bone placed? (12)

What kind of tails had all the early fishes? (13)

What rocks are found above the Ludlow rocks? (14)

What are the Tilestones made of? (15)

What great range followed the Tilestones? (16)

What kind of seasons brought in the Old Red Sandstone? (17)

What was the average depth of the Red Sandstone formation? (18 and 21)

How was the Red Sandstone rock made? (19 and 20)

Where can we see the Old Red Sandstone formation? (22)

Why are fossils seldom found in the Red Sandstone? (23)

What size were the fishes? (24)

Can you describe any of their peculiar shapes? (25, 26, 27)

In what condition were our present dry lands, when the Red Sandstone was formed? (28)

Why do not the rocks of the Old Red Sandstone exist at the present day, as they were first formed? (29)

SECOND DIVISION.

TRANSITION ROCKS.

CHAPTER 11.

MOUNTAIN LIMESTONE.

During the formation of the Old Red Sandstone, we have seen that the power of God was at work, so moving the internal machinery of the globe, that (1) the crust of the Earth was repeatedly lifted up and cast down, by long continued, violent, and awful commotions. When these tumultuous seasons had subsided, a striking change took place on the surface of the Earth. (2) A vast flow of thick muddy lime followed, which ran over the bed of the oceans, and settled in flat layers upon the tilted up under strata. This flow of lime, deposited in enormous masses over the bottom of the oceans, formed a rock, (3) in some places, nine hundred feet deep, which is now termed the *Mountain Limestone.* The rocks of this formation have since been elevated into different mountain ranges ; some of which are fifteen and twenty thousand feet above the level of the sea.

Do you ask from whence came such a large amount of lime? Of lime that covered great parts of the Earth as with a thick mantle! This question no man can answer.

(4) Muddy lime has sometimes been seen to flow out of the mouths of volcanic craters, now in action.

Therefore, He who made all things, might see it good to raise up vast streams of melted lime from the interior of the globe, and to pour them forth through the huge volcanic chimnies, which have ever been ready to act at his bidding.

(5) Some portions of this Mountain limestone might also have been formed by settlements from hot springs, just as both lime and flinty earths are now daily deposited by hot waters, that flow out of different chasms in the Earth.

In Iceland, a boiling hot spring rises up at times like a fountain, ninety feet in height, and as its waters fall back upon the ground, they deposit all around large quantities of the siliceous or flinty earth, which they hold in solution. In the neighbourhood of the Apennine Mountains in Italy, warm waters gush out of the sides of hills, filled with so much lime that they look of a milky whiteness, as if mixed with chalk. The amount of lime held in solution in these waters is so great, that a stick thrown into one of their streams, becomes rapidly encrusted with a white coating. Wherever you cast your eye in the neighbourhood of these hot springs, you see deep ranges of a white stone, usually in a hard and half crystaline condition, formed by the deposition of lime from the waters, which during the wintry floods, had overflown their banks, and on cooling had deposited their lime on the ground. These masses of stone are termed Travertine limestones, or calcareous tufa.

So deep are these layers of Travertine limestone, that many parts of old Rome were built with its stony marbles. And the large quarries dug by the ancient Romans for this purpose, mark, at this day, the very places from which they drew the materials for building their public edifices.

The warmth of the springs, and the carbonic acid gas which is constantly escaping from the surface of these limy waters, greatly encourage the growth of vegetables. The banks of the springs are, therefore, richly adorned with a variety of reeds and water plants. But nearly as fast as the plants send forth their stems and leaves, so does the lime that rises up in the steam and spray of the hot waters, fall upon them, and encrust them over. Insects, attracted by the numerous plants, and by the warmth of the air, settle in numbers upon the foliage, and are often suddenly glued down and covered over. Various shells lodging on the vegetables share the same fate, and become matted together amongst the ever growing masses of the Travertine limestones.

(6) Much lime is also collected from the waters of the ocean, by the mollusks that form shells, as well as by the polypes that build coral walls in numbers vast, and in shapes most various. As these animals die, the decay of their habitations constantly adds to the amount of lime spread over the bed of the sea. But whether our God in forming the Mountain limestone, was pleased to work by one of such means, or by all of them, he has not seen good to make known to man. Our part is therefore, to observe the end that he has brought about—that of forming vast ranges of flat

layers of grey, brown, red, yellow, and black* limestones, that have since been lifted up from the depths of the oceans by volcanic and other agencies.

(7) Mountain limestone is generally made of pure lime, that is of the silvery metal *calcium* (burnt into an earth by its union with oxygen gas), and receiving into every eight pounds weight of its limy earth, one pound of carbonic acid gas. In some places *silex*, (or flinty earth,) becomes mixed with the lime and carbonic acid gas, the rock is then called *Chert;* and when mixed with magnesia, it is called *Dolomite*.

(8) Beautiful marbles abound in this Mountain limestone. Imbedded in its masses are also a few earthy minerals, such as barytes and strontian; whilst the delicate spars of the fluors and carbonates of lime fill many of its crevices. (9) The ores of copper, zinc, iron, and large veins of lead are deposited in its beds. In Derbyshire, the mines are so rich in lead, they seem almost inexhaustible, having been worked ever since the Romans landed on our shores, and are still extensively wrought.

(10) Mountain limestone may be divided into three great ranges. (11) In its lowest beds very few fossils are met with. The thick turbid state of the waters, in consequence of the first great overflow of lime, or from other causes, appears to have rendered the sea unfit for animal life. (12) But in many of its lowest beds, highly coloured marbles, both veined and spotted, as

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* The black colour arises from a mixture of bitumen in the lime.

well as marbles of plain black and red hues, are met with in great masses. Quarries of this description are worked in Italy, in Derbyshire, and in Devonshire.

The middle strata of the Mountain limestone betokens a great change in the condition of the waters, for (13) now madrepores and coralline polypes reared their marble stems like living forests, and every twig and branch, once alive with millions of arms or tentaculæ, in active motion, gathered up the food their inhabitants required. The jelly covering wrapped around each thickly inhabited or separate home, having presented one continuous sheet of brilliant colours, that sparkled in rainbow lustres under the waters of the ancient oceans.*

The layers of the third, or uppermost strata of the Mountain limestones betoken another change, (14) for now we find the limestones filled with countless myriads of strange animals, called Encrinites, or wheel stones, which were somewhat (as already remarked of the lily encrinite) made after the fashion of starfishes set on a jointed stalk. Above thirty species or different kinds of these creatures have been met with in the beds of the Transition limestones. These encrinites must have stood on the floors of the early oceans, which then covered our present continents, as thick as stems of wheat rise in a corn field. One generation constantly succeeding another; for as the lime gently flowed along the bed of the sea, and settled around the encrinites, it gradually buried them in its deepening substance; and no sooner had one range been covered up, than another appears to have sprung into existence over them. Thus one range rose above the other, forming vast depths of solid rock, composed of limy mud and the destroyed coral habitations. The pressure of the waters, and the tendency in the lime to crystalise, forming a marble that extends over large tracts of country, both in northern Europe and in America; everywhere variegated and adorned by its imbedded fossils. With encrinite marbles we ornament our houses, and on many of our mantel-pieces enjoy the sight of the zig-zag polished white skeletons of the encrinite family, set off by the dark limestone in which they are embedded. Yet, often ignorant of the great fact that we behold the relics of animals, that once in their measure enjoyed the pleasure of existence, we regard them with a vacant admiration that yields no praise to Him that made them.

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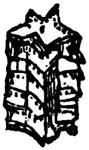
* For further particulars, see Corals, in "Observing Eye," Letters 7 & 8.

Some of these entrochi had round shelly bones, with a hole in the centre; others, with five sides, were called the Pentacrinites. Their arms were long; and sometimes so numerous, that twenty-six thousand separate shelly bones have been counted in the body of one of the encrinites, each shelly bone having been made with care, and often much ornamented.* During life,

Encrinite.



Pentacrinite.

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* See Plate, in page 72.

the whole body of the creature, like the corals, was protected by a gluey skin; their bones, however, are alone preserved. Rooted on the bed of the sea, these living things waved to and fro as their fancy pleased, cleansing, by their energetic thirst for food, the waters around them of many impurities; and so fulfilling the two great intentions of their existence—the enjoyment of life, and the performance of an appointed work. Coral polypes, with some kinds of madrepores, are the present scavengers of our seas, but the entrochi have long since ceased to exist, never being found after the secondary rocks were formed, unless a small and feeble lily encrinite, in the present South Pacific Ocean, may be said to be of the same race.

(15) The chambered shells of the ammonite, nautilus, and orthocera families, floated abundantly up and down in the seas of those times, riding on the ocean waves which then covered our British dominions and present continents. The bivalve, or two shelled arm-footed Brachiopoda families, that fasten themselves to rocks and stationary objects, were numerous. The bivalve shells of the Producta* species swarmed, and several univalve, or one shelled mollusks, that creep along the bottom of the ocean, by a foot or disc placed on the body, were abundant. Amongst these, the Bellero-

Underside of a Gasteropoda Mollusk's Foot, called its Disc.

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[*] See form of Producta Shell, page 75.

phon abounded, and was almost peculiar to the times of the Mountain limestone.

Bellerophon—in the Mountain Limestone.

Trilobites also flourished, but their families were smaller, and of different shapes to those which had lived during the age of the Silurian rocks. Traces of several kinds of fish are found in the Mountain limestone, paticularly their teeth and palates. But no bones of superior animals, nor any pieces of fossil wood, have ever been found treasured up in the layers of this range of rocks. Whilst of radiated or coral kinds of animals, of serpula worms, shells, trilobites, and fish, not less than two hundred and thirty-eight species have been discovered in the rocky layers of the Mountain limestone, all of which, with the exception of two or three species of shells, are entirely extinct races.

Many of the fishes, worms, shells, corals, and encrinites, spread out in beautiful order over its wide extended areas, have their slender edges and delicate fragile parts so well preserved, that it is evident the animals must have lived and died on the very spots in which their relics are deposited; and their family groups lie in such numbers, side by side, and in such positions, as to shew that not one generation only, but generation after generation passed away during the steady, long-continued flow of this lime. No man therefore can count the long tide of ages required for the settlement of this Mountain limestone and its fossils.

The changes that successively took place in animal life during this flow of limy mud, also strongly denote vast lapses of time. First corals appeared, then shells and fishes, and lastly the entrochi. The laws of increase, according to the laws of animal life which still prevail, required time for each generatien to pass from infancy to youth, from youth to middle life, and from middle life to old age. Who then can sum up the ages which this one deposit claims for its own? For man! th short lived tenant of the globe, to make the attempt, is only to display his own littleness. But the contemplation of such works exalts our conceptions of the majesty of God, and his power to work when, where, and how He will, in the eternity of His being. Geology thus witnesses to the value of the Lord's own great name, "I am:" a past, present, unlimited Almighty power.

Marks of violence and dislocation are apparent in all the Mountain limestone strata, arising from occasional outbursts of Trap rocks, which, boiling up like molten lead, drove their substances in between the forming strata, upheaving and fracturing many portions, and causing seams of clay and sand to settle between the layers.

(16) At the close of these great lime settlements, undulating heavings amongst the sea of metals that roll in the centre of the globe, agitated by causes unknown to human beings, seem to have heaved to the surface of the waters, large districts of the newly formed limestones. Upon these risen beds, thin layers of blue

lime and clay became deposited, forming a rich soil for the growth of trees, the nature of which vegetation we shall study in our next chapter.

QUESTIONS.

What changes took place in the crust of the Earth during the formation of the Old Red Sandstone?	(1)
What striking change took place when these tumultuous seasons were over?	(2)
How deep is the Mountain Limestone in places?	(3)
Can you name the sources from which this amount of lime is thought to have arisen?	(4), (5), (6)
Of what substances is the Mountain Limestone made?	(7)
What ores are embedded in the Mountain Limestone?	(9)
What besides ores?	(8)
Into how many ranges can the Mountain Limestone be separated?	(10)
What is chiefly found in the lowest range?	(11), (12)
What in the middle range?	(13)
What in the third range?	(14)
What shells are found in Mountain Limestones?	(15)
What took place at the close of the Mountain Limestone formation?	(16)

SECOND DIVISION.

TRANSITION ROCKS.

CHAPTER 12.

COAL MEASURES.*

The newly risen Mountain limestone beds, mentioned in the last chapter, being surrounded by a warm and moist atmosphere (and filled no doubt with carbonic acid gas, such as floats in the air around the hot springs of Italy), were soon covered with verdure, by a rapid and enormous growth of forest trees; which were simple in their texture, but magnificent in size, and extremely elegant in their forms.

(1) Five hundred kinds of plants have been discovered belonging to these old forests,† most of them of extinct species; whilst those which the most resemble our living trees, are (2) like the plants that grow in the hot lands of India. A few of the trees were of solid wood, like timber firs, but the greater number were of a soft pulpy nature, covered by hard rinds, somewhat like cactus plants. They grew lofty in their height, and thick in their stems. Many of these trees resembled canes,‡ and were fifty and sixty feet in height, piped and fluted from top to bottom, and full of dot-like markings at the places where the leaves had grown

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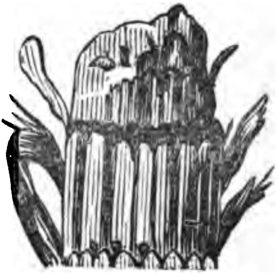
* Coal Measures is a term applied to large deposits of Coal in the Earth.

† Lyell, from Brongniart.

‡ The Sigillariæ—so called from the decay of the leaves that branched out on the stem, leaving their markings like the stamps of a seal.

on their soft pulpy trunks. These trunks are now either filled with sand, or the two sides of the stems are pressed flat upon each other. Others grew with a dome, or ball shaped top, pushing out branches, twenty and thirty feet long, all round the sides of the stem; these branches were covered with rising knobs, out of which probably came the leaves, that are found full three feet in length, embedded in the sandstone around them.*

There is a small plant growing in our ditches, called the Horsetail, or *Equisetum;* a variety of this family grew on the Mountain limestone beds to enormous sizes.† No living equisetum has been found to exceed a quarter of an inch in diameter, whilst the fossil specimens have been found fourteen inches in diameter.



Calamites, an ancient Equisetum.

Ferns are met with in astonishing variety, and of all sizes. Some of the ferns which resembled our common brakes, grew into trees of large dimensions; their summits gracefully bending with flowing leaves.

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* The Stigmaria—a plant that supplied a large proportion of the woody materials of our Coal Measure. It is believed to have been a succulent water plant, and that its leaves floated in the water. Some think it was the root part of the Sigillariæ.

† Frequently called in the Coal Measures, the Calamite Plant.

Others continued lowly, like the green fern that now flourishes in the wooded vales, and on the sunny hill-sides of our own country. As many of these ancient plants branched off into two stems, each being thickly studded with delicate branches and leaflets row above row, they must have formed an entire frond* of great lightness and beauty. A hill-side clothed with these delicate fronded ferns, must have rolled its mimic waves of soft green, to every light breeze that stirred the depths of the old carboniferous forests. Such a light and flexible covering, gracefully waving over undulating plains and gentle acclivities, must have finely contrasted with the dark stately trunks of the fluted Sigillaria and the lofty columns of the noble Lepidodendra† or scaly trees.‡

Amongst the flowers and leaves of these eastern-like plants floated the busy hum of insects. (8) In Coal-brook-dale in Shropshire, and in a few places on the continent, the hard coats of beetles, of one kind of moth, and the wings of the dragon-fly species, have been found embedded in the clay that once surrounded their forests. The fossil remains of an air-breathing scorpion, of one land crab, and of three lizards have also been seen. The largest lizard from the size of its head, must have measured three feet six inches in length; and footprints of two other creatures of the lizard or frogtribe have also been found in the sandstone of the coal measures in Pennsylvania.

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* Frond—a botanical term for leaves of flowerless plants, a kind of stem, in which the leaf and branch are united—a leafing peculiar to Palms and Ferns.

† So called from scale and tree, as their trunks had a scaly appearance.

‡ Slightly altered, from a lecture by Hugh Miller.

The ancient forests of cactus-like plants, belonging to the Coal Measures, appear to have grown (4) in large lagoons, or broad sheets of shallow fresh water, and to have extended far and wide over the raised lands. Great part of Northumberland, Lancashire, and the counties that surround Derbyshire, with large tracts in the south of England, Wales, and Scotland, were covered by these forests. In the United States of America, a district of coal mines near the Alleghany mountains runs for nine hundred miles in length, and in some places two hundred miles in width; thus betokening that vast forests formerly covered those extensive tracts of land. Fresh water shells, particularly a mussel called the unio, lie buried in great abundance in the soil that once surrounded these forest trees. (5) The land also upon which the forests grew, being little raised above the level of the sea, was subject to frequent inundations from the ocean, and as the sea-waters, loaded with sand and mud, came sweeping along the ground, they deposited their soil around the stems of the giant trees, thus partially burying them up. (6) Salt water shells and fish, driven in by the waves, thus became intermingled with the relics of the forest lands. Not less than one hundred and fifty species of fish have been found buried in the coal strata; ninety-four of these belong to the family of the shark and ray fishes, but all are unlike the living species now in our seas.

(7) So wonderfully did the crust of the Earth heave up and down at this period, that the sinking of its surface caused forest after forest, in some parts of the world, to descend gently under ground, but not so rapidly as to destroy the trees, which from their moist nature, could live like our reeds after they were partly enveloped in soft mud. When the ground had sunk, in the course of a long period of years sufficiently low to bury up a forest, a new one appears to have sprung upon the accumulated soil over it; flourishing away in its turn, until by the same slow process, it had sunk low like its predecessor, to be again succeeded by a fresh growth of plants. "One of the finest examples in the world of a succession of fossil forests of the carboniferous period, is laid open to view by a natural section in the lofty cliffs, bordering a branch of the Bay of Fundy in Nova Scotia. In Cape Breton, a coal-field is described by Mr. Brown, measuring one thousand eight hundred and forty-three feet in depth, in which is clear evidence of the existence of (8) at least fifty-nine fossil forests ranged one above another.*" (9) In coal mines, both in America and England, some of the trees are found rooted and fixed in the ground in an upright position, but this is the exception to the general rule, for they are mostly tossed about in all directions.

Towards the close of the vast periods of time in which the plants of the Coal Measures had been grow-

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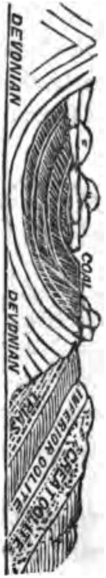
[*] Lyell's "Elementary Geology," page 97.

ing, tumultuous shakings convulsed many portions of the earth; and lava, of which Trap rocks are formed, flowed freely out of huge chasms on the Earth's surface, as well as from the yawning craters of volcanoes. The limestone strata reeling to and fro by the tremendous heavings of these earthquakes, became fractured and broken, and in many parts sunk down into the form of large basins or troughs, many hundred feet in depth. As the waters rolled through these vast hollows,(10) they swept into their depths the prostrated forests of fir and cactus-like trees, which mixed up with layers of sand and mud, remained entombed for countless ages, and were successively covered over by newly forming soils or rocks, many thousands of feet in thickness. These plants, by the arrangement of our Heavenly Father, became in their dark chambers saturated or filled with (11)bitumen* and sulphur; which substances, under a heavy pressure, have destroyed the woody parts of the plants, and changed them into mineralised coal. In the blackest coal, the gum and woody fibre of the plants is the most perfectly destroyed; charcoal and bitumen alone remaining, except as they are united



Coal Basin in Mountain Limestone.

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* Bitumen—a brown substance; an oily pitch formed of Carbon and Oxygen, and Nitrogen gasses.

to a few earthy particles, which particles, in the form of ashes, fall under our grates from burning coal.

(12) All trees of the peculiar species of these coal plants, would have been entirely lost, had not portions of their stems, and groups of their leaves been enclosed in thin layers of the clay and mud that overwhelmed them. By such means, five hundred varieties as we before remarked, have been preserved. Much of the foliage enclosed in these shales or thin muddy layers, is now as clearly to be seen as if it had been but lately stamped upon its blue plaister beds. The very nuts of some trees called the chara balls, when first opened, are still fragrant with sweetness.

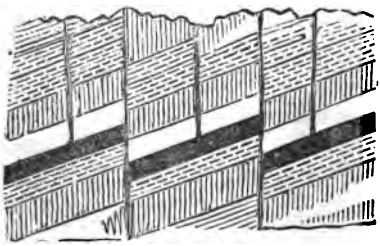
Pactrypteris—A fern on clay.

The roofs or top ranges of the largest seams of coal, are sometimes covered by many coatings of these thin layers of dried blue clay, most of which are filled with beautifully preserved plants. As the coal is dug from under this shale, the roof often gives way, and falling down for considerable distances, unveils to the extreme delight of the beholder, the fairy scene as it were of another world.

One of the finest exhibitions of this kind is in Bohemia, near Prague, and is described in nearly the following words by Dr. Buckland :—"The most delicate imitation of living foliage upon the painted ceilings of Italian palaces, bears no comparison with the beauteous profusion of extinct vegetable forms, with which the galleries of these instructive coal mines are overhung. The roof is covered as with a canopy of gorgeous tapestry, enriched with festoons of most graceful foliage, flung in wild irregular profusion over every portion of its surface. The effect is heightened by the contrast of the coal black colour of the vegetables, with the light ground-work of the rock to which they are attached. The spectator feels himself transported, as if by enchantment, into the forests of another world; he beholds trees of forms and characters now unknown upon the surface of the earth, presented to his senses almost in the beauty and vigour of their ancient life; their scaly stems and bending branches, with their delicate apparatus of foliage, are all spread forth before him little impaired by the lapse of countless ages, and bearing faithful records of extinct systems of vegetation, which began and terminated in times long—long gone by, and of which these remains are the faithful historians."

In the dark coal mine, the labouring man not only beholds (by the light of his flambeau), the once living tapestry of an ancient forest stamped on the vaulted roof; but on every side he can trace the wonder-working finger of his Creator. He finds the forest wood changed into coal; he finds it placed, to his great convenience, (13) in basin-like troughs, by which arrangement both ends of its seams are thrown up to the surface of the Mountain limestone; (14) and again he finds in the wide extended coal fields, walls of clay dividing its treasures into many separate compartments, by which means the waters in the mine are stayed from overwhelming him as he works out its mineralised wood.

Had the Coal Measures been allowed to remain far down in the Earth, concealed underneath all the later formed rocks, man never could have laid his hand upon their strata. But tilted up by vast disturbing powers from beneath, their black vaults are now readily entered, and their coal worked out. And by the force that lifted up and shivered the Limestone rocks, are formed the numerous divisions at present found in the coal fields.(15) For as one portion of the coal basin, with its accompanying clays and sands, was driven by volcanic force higher than another, the broken edges of the limestones became violently rubbed against each other, by which means walls of clay, which are impervious to water, were formed between the coal; thus dividing the whole deposit into many chambers, and effectually stopping the water, which abounds in the vast limestone basins, from flowing forwards out of one chamber into another.



Fault, or broken Strata in Coal Field.

Without some such provision, no art of man could have drained the extensive deposits of coal which are frequently stretched out for miles. Steam engines can do much in raising water, but they never could have exhausted the deep subterranean springs that run the length and breadth of the Coal Measures. Sometimes trap rocks run through the coal chambers, dividing them as the clay walls do, at which times the clay that lies near the trap has been converted, by its heat, into a hard jaspery substance, and the coal, for some distance, into charred soot.

To the possession of coal mines, England owes much of her foreign and domestic prosperity. With coal we prepare our food, and heat our forges and furnaces. By setting our steam engines in action, coal enables us to pump and to dry the deep caverns of the earth, in which lie the valuable ores of tin, iron lead, silver, and copper. It enables us to excavate, to carry, draw, lift, hammer, spin, weave and print. One bushel of coal under the boiler of a steam engine, gives an artificial strength to man, by which he can lift ninety-seven millions of pounds of water one foot high. It sends him travelling over the earth with almost the speed of a bird ; and by its aid, he can stem the opposing winds and tides on the ocean's waves.

Who can read the history of this rich mine of ancient plants, and learn that they have been pressed down in vast numbers, then stored up in the dark chambers of the earth for millions of ages, and again lifted up within the reach of man, and not trace in such an arrangement the hand of a gracious and kind Creator, acting under the grand design of preparing all things for the good of that intelligent race of beings to whom he has given this ball of Earth. In return for which the great Giver has condescended to tell us, that he looks for a grateful tribute of adoration, praise, and thanksgiving.

We have now finished the Transition series; a vast range of muddy, pebbly, and limy rocks. In Wales, and the adjoining parts of England, its Silurian, Devonian and Carboniferous strata alone, amount to a thickness of more than six miles.* And as from the nature of the fossils which they contain, each separate layer must have been laid down in rather shallow seas; it is clear, that to admit of this vast depth of rocks accumulating under the waters, the crust of the Earth must have been constantly sinking, balanced by the hand of Omnipotence in its downward movement, during the whole period of the Transition formation.

In our next chapter we shall begin the history of the Secondary series of rocks.

QUESTIONS.

What soil soon covered the risen Mountain limestone? See end of Chapter 11.

How many varieties of plants have been found in this series? .... (1)

Of what kind of woods were the Coal Measures formed?... (2)

What insects have been found amongst the Coal Measures? (3)

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* Lyell.

In what kind of situations did the plants of the Coal Measures grow? .... (4)

To what inroads were the plants of such low lands subject? (5)

What was brought by these inundations amongst the trees? .... (6)

What caused the growth of one forest over another? ...... (7)

How many forests have been seen one over the other in Nova Scotia? .... (8)

In what position are the trees of the Coal Measures now found? .... (9)

Into what were they often swept? .... (10)

What minerals changed the woody fibres of the plants into coal? .... (11)

If the trees were altered by minerals and pressure into coal, how do we know the forms of their stems and leaves? .... (12)

What advantage to the miner is the arrangement of coal in basins or troughs? .... (13)

Of what use are walls of clay in coal mines? .... (14)

How were these walls formed? .... (15)

THIRD DIVISION.

SECONDARY ROCKS.

CHAPTER 13.

GENERAL REMARKS UPON SECONDARY ROCKS.

THE Transition series ended by the overthrow of the Mountain limestone, and of the trees that form the Coal Measures. From that period a great alteration took place in the condition of our planet. (1) Metallic veins henceforward become rare—the rocks less crystaline, and from being more soft and earthy, they soon yielded a vegetation adapted for the higher orders of animals.

The rocks that immediately followed the Transition series are termed the *Secondary Formation.* This formation rests (2) unconformably; that is, in flat beds upon the uptilted Transition rocks, and is of vast depth, extending from the Coal Measures (3) up to the chalk.* (4) It consists chiefly of enormous deposits of limestones, varied in their qualities, such as in the Oolites and the Portland stones; all of which strata are intermixed with seams of clay, sandstones, and conglomerates.

We have seen that during the growth of the Coal Measure plants, many large portions of the crust of the earth, previously under the sea, had been raised to the surface of the waters. The fossils in the Secondary rocks denote the sinking again of the same lands. And by their varied characters we also learn, that the whole Secondary series, with one small exception, was deposited (5) in open seas, which in some places were deep, in others shallow, and were generally dotted over with islands.

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* See the Chart of Rocks by Title page.

(6) The Secondary strata enclose deep beds of salt, drifted portions of plants, many kinds of coral, some new species of crustacea,* fishes, shells, the foot prints of birds and of huge reptiles. The earth, however, appears to have yet continued in too agitated a condition to render it a suitable residence for many warm blooded inhabitants, as, excepting the feet marks of birds, few traces of land animals are found in this formation.

The general appearance of the Secondary rocks, not only teaches us that immense streams of lime overflowed the ocean at various intervals, (7) but that long continued settlements of mud and sand rose, layer by layer, in the course of ages, into stupendous masses many thousand feet in depth. Do we ask, from whence came these prodigious collections of lime, mud, and sand? Lime may have been supplied by springs, by volcanic agencies, and by the waste of limestone rocks, shells, and corals. (8) But enormous amounts of boulders, and of muddy sediments, can only be obtained from the waste of continents, from their broken crumbling surfaces having been drifted into deep waters by rivers. From whence, then, came the sediments that form our Secondary rocks? (9) Our present continents could not have supplied those sediments, because it was on their very bosoms, whilst buried under the sea, that the Secondary deposits were gradually laid. Other lands must, therefore, have existed; and in order to drift their heavy detritus far over the bed of the seas around them, those ancient lands must have been navigated by rivers deep and wide, possessed of powerful streams, opening into the ocean by mouths far exceeding in size those of the present Ganges and Mississippi rivers. This view is supported on the fact, that after measuring the mud annually brought down in the waters of the Ganges, it is found that the whole of its deposits during the last six thousand years, would not form a rock above one hundred feet in thickness; whilst the thickened waters of the ancient rivers, rushing from their broad mouths with gigantic force over the floors of the ancient oceans, have left in our Secondary rocks, deposits that are many thousand feet in depth.

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* For a description of Crustacean animals see "Observing Eye," Letter 17.

Tracts of land that could give rise to rivers so large, and lade them so heavily with sediment, must have possessed lofty mountains, which, drinking in their moisture from the passing clouds could, from their height, send their streams in dense volumes rolling along the length and breadth of widely extended countries. Where then did those mighty lands exist? No such immense tracts are now to be found in our Atlantic, Indian, or Pacific oceans. Yet the fact is ever before us, that a large proportion of the rocks upon which we live, have been actually formed out of the crushed and water washed detritus of some such unknown continents. So entirely however have the parent lands of the Secondary rocks disappeared, or been sunk beneath the waves of the Atlantic and Pacific oceans, that, excepting as a few of their mountain tops may form our ocean islands, it is only by the vast depths of soil they have left behind, that we can trace any proofs of their former elevation. But this proof is irresistibly strong, for the piles of mud and sand removed, or swept from off their crumbling surfaces into the sea, having become in the course of ages hardened under the sea waves into solid rock, and since lifted up to bask in the light of the sun, form the very soils upon which the millions of the present human family find their firm footing, support, and riches.

(10) Sand,* clay, and lime, are the three principal substances which constitute the external covering of the globe. Each one of these earths constitutes by itself a poor soil, but when the three are blended together, they yield ample support to vegetation. We are, therefore, compelled to admire the anticipating wisdom of our Heavenly Father, who mixed at this era of the

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* Sand or flint is composed of the silvery metal silica, of oxygen gas, clay, and some water and iron. The silvery metal, silica, is never found alone in nature—it instantly unites with the oxygen in the air, and is then called silex, or quartz.

world's history, by means of river transports, the sharp crumbling particles of siliceous granites, the caustic particles of limestones, and the adhesive clay of the alkaline* trap rocks. (11) By blending these different earths together, in the rapid movements of river-waters whilst passing through vast continents, a soil has been formed, so adapted for the growth of the vegetables which man requires for himself, and for the domestic animals he has collected around him, that the greatest populations in the world have found it good to place their habitations upon the once muddy strata of the Secondary and Tertiary rocks. Granite districts are but little peopled—siliceous sandy deserts still less so; but wherever beds of lime, clay and sand are mixed by natural causes, or are so placed that man, by his own industry, can work them together, there the human family live and flourish.

QUESTIONS.

What change took place in the rocks formed after the Transition series? .... (1)
How do the Secondary rocks rest on the Transition series? (2)
Up to what rock does the Secondary formation run?...... (3)

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* Alkalies are potash and soda. Many trap rocks hold much of these Alkalies, and crumble down into rich soils—all vegetables requiring some potash and soda.

Of what do the Secondary rocks chiefly consist? .... (4)

Under what did the present dry lands of the Earth lie during the formation of the Secondary rocks? .... (5)

What do the Secondary rocks enclose? .... (6)

Besides a vast overflow of lime, what does the general appearance of the Secondary rocks teach us? .... (7)

From whence came all the mud, sand, and boulders, that form our Secondary rocks? .... (8)

How do we know these sediments must have come from other continents than our present lands? .... (9)

What earths are required to form a good soil? .... (10)

By what natural means were these earths mixed during the Secondary and Tertiary periods? .... (11)

THIRD DIVISION.

SECONDARY ROCKS

CHAPTER 14.

NEW RED SANDSTONE FORMATION.

LOWER NEW RED SANDSTONE.—MAGNESIAN LIMESTONE. UPPER NEW RED SANDSTONE.

THE lowest rocks in the Secondary series are called (1) the New Red Sandstones. They are divided by geologists (2) into three ranges. First, the Lower New Red Sandstone, consisting of layers of sand and conglomerates. Secondly, a depth of Magnesian Limestones, of yellowish and red brick hues. And thirdly, the Upper New Red Sandstone, formed by many red and yellow striped and spotted marls, with sandstones containing salt.

Many of these New Red Sandstone rocks can only be distinguished from the Old Red, in the Transition series, (3) by the fossils which they contain. We have before remarked, that the same species of animals frequently passed on from rock to rock, until some change in the state of the globe checked their growth. In a higher series the same fossils often re-appear; but should the place of the absent species be found to have been supplied by a new style of form, we may be sure that the lost species will never more be seen. It has been obliterated or wiped out of the earth.

It is by this rule of alteration in animal life, and

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not by the appearance, colour, or quality of any stony deposits (as we have before remarked), that the age and situation of rocks can be determined.

The whole series of the New Red Sandstones were deposited upon the Transition rocks, (4) in unconformable strata. In many places they fill up hollows in the surfaces of the more ancient rocks, as well as deep vallies, that earthquakes and the rush of waters had rent open. The uplifting in after ages of all these rocks, by a general elevation of the crust of the globe, has shewn out the course of the New Red Sandstone, as it runs down (5) the western side of England, from Lancashire into Devonshire, its depth varying from one hundred to five thousand feet in thickness.

The Lower New Red Sandstone is of various colours, and in Germany is called Rothliegende.

(6) The wild uproar that prevailed on the face of the Earth, during the breaking up of the Mountain limestones and of the Coal Measures, is (7) strikingly displayed in the stony records of the Lower New Red Sandstones, which are chiefly composed of sand and conglomerates, formed out of porphyries, basalts, amygdaloids, shivered fragments from the Coal Measures, as well as from the under Grau-wacke and Slate rocks. The separate fragments of these rocks vary in size, from that of a pebble to masses of many tons in weight, all blended together in strange confusion, according as the violence of the disturbing powers rent the fragments from their native beds. Tossed into

agitated currents of waters, these broken masses of rock were driven forward, with different degrees of violence to greater or lesser distances, and finally sank into beds of lime, of fine sand, or of red clay. In these beds they became cemented together into solid ranges of rock, that rest unconformably* upon the uplifted under series.

A broken cliff, named Petit Tor, at Babbicombe Bay in Devonshire, finely displays the formation of these lower conglomerates, being a compound of huge masses of beautiful Mountain limestone marbles many tons in weight. These masses, whirled from their native rocks, fell into deep beds of reddish clay, supposed to have been produced by the decomposition of Trap rocks. Conglomerates of smaller materials were formed upon the surfaces of these marble breccias. When violent convulsions again rending open wide fissures in the whole pile of the brecciated rocks, the gaps became filled up with fresh conglomerates, which accumulated in layer upon layer over the entire surface of the pile.

The Lower New Red Sandstone occurs in all parts of the world, and is recognised by the fossils which chiefly rest in its separating seams of clay and lime. These fossils are few in number. (8) The agitated condition of the globe, and the turbid state of its waters, were probably not favourable to the increase of animal life, whilst the constant rolling, grinding action of moving gravels, and the presence of oxide of iron, which imparts to this formation its dull red hue, tended also to destroy the few animals and vegetable remains that fell into its strata. Those that have been preserved, generally resemble the genera, and species found in the Transition rocks.

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* Unconformably, see Sketch in Note on page 27.

The Mountain limestone, which forms the under rock of the Downs, near Bristol, contains huge hollows that are filled with conglomerates of this series. In the paste of red and yellowish Magnesian earth, which cement together the boulders and pebbles of this conglomerate, are found the teeth and fractured bones of large lizards, such as were occasionally met with in the Coal Measures.

A calm appears to have followed the stormy deposition of the Lower New Red Sandstones. (9) During this tranquil period, several strata of limestones, composed of equal quantities of lime and magnesian earth, were settled over vast areas of the ocean's bed, to the average depth of three hundred feet. These beds of Magnesian limestones are termed the *Permian Group,* from a district in Russia called Perm, where the Magnesian strata has been minutely examined. In Germany, the compact limestones of this series are called Zechstein. Its brecciated limestones are named Rauchwacke. And its lime, settled in balls (or concretionary limestone), is called Stinkstein. The Magnesian beds, with their strata of clays and sand, are of several colours. When tinged with hydrate of iron, they vary from pale fawn to deep salmon and yellowish hues, and when coloured with oxide of iron, they are of a red hue. (10) In England, the Magnesian strata can be traced from Durham, through Yorkshire, and down the western side of the kingdom. In (11) Russia, it extends over a circuit of four thousand miles, a space equal to twice the size of France. In Germany it is largely developed, and is rich in fossils.

Some of the Magnesian limestones look cracked and broken, as they had been greatly disturbed and pressed after their formation. Others present, as on the banks of the Severn, the singular appearance of ranges of balls settled into a bed of the same paste as that of which the balls are formed. The round concretions having probably been caused by peculiar circumstances attendant upon the settlement of the lime.

Many Magnesian limestones, when first broken, present a glittering saccharine appearance, and on being rubbed give out a fœtid scent. They easily cut when first removed from the quarry, and afterwards become hard. On this account Magnesian limestones afford excellent building materials, and have lately been chosen as the most durable stone, for the erection of the new Houses of Parliament.*

(12) A change of form in animal life is distinctly visible in the Permian group. The old species of living creatures that flourished in the Transition era gradually die out and new species appear. Wheel encrinites become rare. The spirifer shell is gone, and

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* The stones for the Houses of Parliament were dug from quarries at North Austone, in Yorkshire, and near Worksop, in Nottinghamshire.

the producta but rarely seen; whilst out of one hundred and sixty-six species of animals which have been closely examined in the Magnesian group, one hundred and forty-eight species are peculiar to its own strata. In forty or fifty species of fish, only one is met with that resembles those found in the lower formations. The one sided tail, or the back bone carried forward into the top lobe is, however, retained; a peculiarity universal in all the early fishes, and which, in the eight thousand species now swimming in our seas, is only to be found in the shark and ray families. This one sided tail itself becomes rare after the deposition of the Lias, which is a range of rocks a little above the Magnesian limestones, whilst saurians or large lizards, with crocodile teeth, increase immensely in the next series of rocks; and what is remarkable, as the most highly finished order of fishes in some degree decline, so the reptile world advances. In the Grau-wacke rocks, fish had taken as it were, the ruling place in animated life. Many of their tribes possessed a much higher conformation of organs than our fishes. Their brain was more developed; their scales of solid bone, as well as the bones of the head, were dexterously inserted one into the other. The outside of the bone was ornamented with markings and highly polished with enamel; whilst the inside was lined with a skin full of veins. Their eyes were large, their mouths thickly set with teeth at the edge of the jaw, and often backed by an inner row of thinly set saurian or reptile teeth. The muscular backbone of these cartilaginous* fishes was made something like the vertebræ of reptiles, and the air bladder inside the body approached to the character of lungs. But as the reptile world advanced in perfection, so fishes are found to have declined in their organs of superiority. Thus the study of Geology brings to light not only the grand march of fresh actors on the scene of life, but the knowledge that a singular depression took place in the forms of creatures, which previously to the introduction of a new and higher race, held the chief rank amongst living animals.

This elevating and lowering arrangement continually occurring, marks the selecting choice of *One Mind*, ruling and presiding over all life, throughout all ages.

In several of the light and dark shales which accompany the under layers of the Magnesian limestones, shoals of small fishes have been met with. In the bituminous shales of Germany, many of these fishes are remarkable for the distortion of their attitudes, and for their burnished golden appearance, being highly coated with iron pyrites. Fish of a similar form are met with in the slaty shales of Sunderland, and in Durham, which fact affords an interesting proof (13) that the waters of one sea, the home of the same shoals of fishes, swept, in the Magnesian era, over most of the present inhabited portions of Europe.

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* Cartilaginous Fishes.—Those tribes which have a muscular skeleton, and no hard backbone inside the body—the solid frame-work being placed on the outside. Two-thirds of the early fishes appear to have been formed in this fashion. The rest had firm skeletons like the present races.

QUESTIONS.

What are the lowest Secondary rocks called? (1)
Into how many ranges is the New Red Sandstone divided? (2)
How are the New Red Sandstones distinguished from the Old Red? (3)
In what way were the New Red Sandstones settled on the Transition series? (4)
On which side of England is the New Red Sandstone formation seen? (5)
What does the New Red Sandstones betoken? (6)
How is the wild uproar shown? (7)
Why are there not many fossils in the New Red Sandstone? (8)
What deposit followed the first New Red Sandstones? (9)
Where is the Magnesian limestone stratum seen in England? (10)
How extensive is it in Russia? (11)
What appearance is there amongst the animals of the Magnesian limestones? (12)
What does the existence of fossil shoals of fish in Germany, and in the north of England, betoken? (13)

For the relative situation of the Red Sandstones and Magnesian Limestones, look at the chart of the Order of Rocks.

THIRD DIVISION.

NEW RED SANDSTONE.

CHAPTER 15.

THE TRIAS FORMATION; OR, UPPER NEW RED SANDSTONE

DIVISIONS.

English.	*German.*	*French.*
1st.—Saliferous and Gypseous shales, and Sandstones	**Keuper**	**Marnes irisées.**
2nd.—Wanting	**Muschelkalk...**	**Calcaire coquilliere.**
3rd.—Sandstone and Quartzose Conglomerate	**Bunter-Sand-stein.**	**Grès bigarré**

(1) UPON the Magnesian limestones are found vast settlements of clay and marl shales, that run from one thousand, to one thousand five hundred feet in thickness, and are of red, green, and grey colours; which shales, intermixed with red and white sandstones, (2) are called the Trias Formation.*

The beds of this series are not generally rich in fossils, but (3) they contain impressions of remarkable animal footsteps, (4) and immense beds of salt. In Germany, the Triassic group is two thousand feet in depth.

Such a pile of coloured hardened muds, averaging one-third of a mile in thickness, is a wonderful fact for the enquiring mind to contemplate. No turmoil is stamped upon its layers! Every bed betokens a quiet

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*** The term of Trias is given to this formation from its rocks being in Germany divided into three distinct bands.**

settlement. Do you ask from whence came such masses of finely pounded soils? To meet this question we must examine the present movements in nature.

Cast then your eye over the eastern side of the Grampian mountains in Scotland, and you will see that the whole of their granite rocks, their gneiss, mica, and clay shales, are overspread with powder and dust, derived from the crumbling away of their surfaces; which dust, from the presence of oxide of iron, is stained of a red hue, precisely the colour of the Old and New Red Sandstones. Now this alluvium, or red earth on (5) the Grampian mountains, merely requires to be swept down to the sea, or into a lake, to form strata of red sandstones and red marls, like the masses in the Devonian and Triassic rocks.

The terrible effect of such washings from off high mountain sides, was awfully experienced in the valley of Chamonix in Switzerland, during the Autumn of 1852. Heavy rains having swollen the torrents that flow down that region of the Alpine range, their waters rushed in foaming cataracts over the rocky precipices, filling the river Arve with deep eddying waters, until it rose in places twenty-five and thirty feet above its usual level. In this dreadful calamity, the inhabitants of the valley were called out by beat of drum, to aid each other. But so rapidly did the river rise, nothing could stay its waters. The valley was quickly one scene of ruin and tumultuous noise. The movement of huge boulders, which the river torrent forced along, literally shook the ground, and as their masses drove forward and struck upon the rocky bottom, the sound of their concussion filled the air like growling thunder. The long reverberations of falling avalanches of snow on the mountain summits—the crash of trees and of timber on the low lands, with the hissing of the toppling waters in the river, and down the cataracts, formed an awful chorus. Rushing up the steep ascents, the poor cottagers beheld with tears and wringing of hands, the planks and roofs of their chalets and timber bridges whirling down in the river waves, which boiled and chafed along in huge masses of water, resembling liquid mortar. This deluge of thickened waters, sweeping over the valley, drowned their cattle, swept away their flax crops, left out to dry, and covered their scanty supply of corn and food with thick layers of white mud, composed of the debris of granite and shale rocks, and to such a depth, that it is calculated many years will be required to remove its masses.

By noticing such facts, which on a small scale are now passing on the Earth, we become acquainted with a source, by which, in the course of long periods of time, deep beds of smoothly arranged muds might be laid one over the other, so as exactly to resemble the vast Triassic formation. (6) The green colours of the Triassic mass being derived from the decomposition of hornblende and mica, which often contain, with their oxide of iron, some chlorite, a mineral that imparts a green hue to earthy bodies.

The variations of soil, so apparent in the ancient rocks, also arose from causes that are still in action. Fine sediments of sand and clay are at the present day, constantly carried down to the ocean in river streams, and are swept away in immense quantities from the wasting sides of sea cliffs, by the powerful action of the waves, which tearing down the land on the coast, resettles its materials again in layers under the waters of the sea—the coarser particles falling first, and the finer being driven onwards.

(7) Alterations in the currents of the sea, the rise and fall of land, or changes in the bed of the ocean, often send these drifts of mud and pebbles into new channels, and cause other drifted materials to flow on, and settle upon the former bed. Such are the facts often witnessed in the old strata; where sand is seen to rest upon clay beds, ranges of pebbles above the clay, and again, in consequence of another change, sand over the pebbles. The Triassic group is remarkable for this changing mode of strata, as well as for its striped hues.

The lowest strata in the Trias is a deep deposit of red and white flinty sandstones, intermixed with a few red and green shales, all of which contain but few fossils. In Cheshire and Lancashire this group is six hundred feet in thickness. Near Coventry, in Warwickshire, (8) the trunks of *coniferous trees, full one foot and a half in diameter, have been dug out of a

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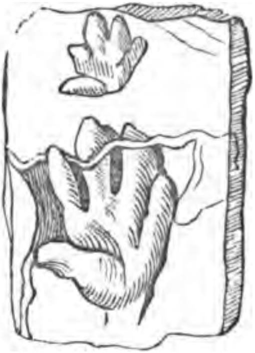
* Coniferous, or cone bearing trees like the larch and fir.

red sandstone, mixed with conglomerates, the rings of their annual growth being in some cases distinctly visible. These trees, uprooted from their native lands, must have fallen into river water, and been drifted into the sea flowing at that period over our present Warwickshire, and sinking into the sand collecting on its bed, became perminently imbedded.

(9) Footsteps of several air breathing animals, the marks of large worms, and of small crustacean animals, in the act of creeping over the soft muddy shores that sloped down to the waters of the ancient seas, are distinctly stamped upon some of the layers of this formation.

The print of the human foot, stamped upon the sandy shore of his solitary island, did not more fully convince the startled Robinson Crusoe that another man besides himself trod the ground of his island, than the foot tracts of numerous living creatures convince us, that animals, and even quadrupeds existed in the Triassic ages, long before man was created.

At this period of the Earth's history also commences a vast assemblage of gigantic reptiles, whose numbers, judging by their relics in the rocks, were three times more numerous than the reptiles of the present day. The largest of these reptile bones have been found in Germany, enclosed in the sandstone called the Muschelkalk. In the rippled flags of the new red sandstones of Germany, Scotland, and England, have also been discovered new and strange footsteps, apparently formed by the deep steppings of some large quadruped padding its way along the sandy shores of those early periods. The fore paws in these footprints are usually much smaller than the hinder, being four inches long and three wide, whilst the hinder are eight inches in length, and five in breadth. The general form of the footprints much resemble the shape of the human hand.



Footmarks of an unknown Animal, supposed to be a Frog of immense size, from the sandstone of Hildburghausen.

At the Storton quarries, near Liverpool, casts of the same kind of footprints have been found on the clay shales, that lie between the white quartzose sandstones, and in such high relief that they afford models of the feet, toes, and claws of the animals which trod on the clay.

The discovery of these strange feet-marks aroused the attention of the German, English, and American naturalists. For some time they concluded they were either the feet prints of turtle, or of some kind of kangaroo. But within a few years, in the very strata in which these feet marks occur, the shoulder, leg, and head bones, with the jaws and teeth of some huge order of crawling animal having been found,* Professor Owen has at length decided, that these remarkable foot prints must belong to (10) an enormous species of frog,* far exceeding in its dimensions any living creatures of that tribe. The head of one of these enormous batrachians, or frogs, placed by Dr. Lloyd in the Warwick Museum, measures in length eleven inches, and in width six inches, whilst the head of a living frog does not exceed half or three-quarters of an inch.

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* In the Keuper sandstone of Germany. and also discovered by Dr. Lloyd in the New Red Sandstone of Warwickshire.

From the size of the teeth found in a separate state, it is supposed that some of these ancient frog-like creatures were of far greater dimensions than the fossil head in the Warwick Museum. Professor Owen has drawn a model, on a small scale, of this animal, such as its relics lead him to conclude it must have resembled.

Frog of Red Sandstone restored.

From the air breathing holes in the skull, it is clear that this batrachian lived chiefly on land. On escaping from the egg, the young of the frog tribe live in the water, breathe by gills, and have round bodies and long tails; but after passing through some changes of form, they lose their gills and acquire feet and lungs. The skull of the finished frog is flat, and the teeth small and sharp.* They have no ribs, and the only species that possesses a tail is called a salamander.

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* The Batrachian order.

No history has recorded the creation or destruction of the formidable species of frogs whose remains are buried in the Triassic rocks, but they have "left memorials of their passage, enduring and indelible."

Dr. Buckland remarks, in nearly the following words :—Armies of men have triumphantly pursued their march, trampling down the most mighty kingdoms of the world, but the winds and the storms have utterly obliterated the ephemeral impressions of their course. Not a track remains of a single foot, or a single hoof, of all the countless millions of men and beasts, whose progress spread desolation over the Earth ; whilst the reptiles that crawled, thousands, and it may be millions of ages ago, over the half finished surface of our planet, have left their footsteps impressed upon the sands of their native German, Scotch, and English shores. Exposed afresh to view, our curious and admiring eyes behold their feet marks stamped upon the rock, distinct as the track of the passing animal upon the recent snow ; in mockery, as it were, of the fleeting, perishable course of the proudest potentates amongst mankind.

Not only are the footsteps of various animals to be seen as they were stamped on the layers of soft sand or mud over which they passed, but impressions of the very rain drops of the Triassic period are preserved in the Earth upon which they fell. And so gently did the next coming wave deposit its sand over the rain dimpled surface, that many of the recently exposed layers of this strata present a blistered, or warty appearance. And in some cases, the slant of the rain drops marks the quarter from which the storm came.

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* The toad has no teeth.

Slabs of stone on which these rain drops and feet marks are stamped, have frequently many zig-zag lines running across them. These lines were once cracks in the wet mud, formed by its being quickly dried under a sharp wind or warm air, and becoming afterwards filled with fresh sand or mud, have left the raised ridges we so often see on the face of stony layers.

Feet marks of a character still more remarkable than those of the batrachian order, have recently been discovered amidst a multitude of other impressions, on thin layers of a clayey sandstone, in the States of Connecticut and Massachusets, in America. These feet tracks are scattered in patches over an extent of nearly eighty miles, from north to south, and (11) through a depth of more than a thousand feet of rock, which rock was probably thousands of years in the process of formation.

These feet marks, according to Professor Hitchcock, consist of four sorts of lizards,* two kinds of turtles,† six kinds of frogs,‡ thirty-two bipeds (thirty of which were birds), and twelve quadrupeds. In one district the Professor counted two thousand such marks, and Sir Charles Lyell in another district remarks, that owing to the number of footsteps of extraordinary appearance, which covered the entire surface of the shale, the whole face of the rock was irregularly jagged, so that not one step could be distinctly traced; the face of the ground resembling the confusion occasioned by a flock of sheep passing over a muddy marl. On withdrawing from this area, the confusion gradually ceased, and the tracks of a two legged animal became clear. The foot marks were equal in size, and equal in distance from each other; the toes of the two foot prints turning alternately to the right and left. (12) Such lines mark the walking progress of a bird! But the immense size of the foot prints, exceeding those of our largest living ostriches, again perplexed the first discoverers. Each foot measured eighteen inches in length, and fourteen inches in breadth; the stride between the two feet was forty-eight inches, and every step had sunk so deeply into the clay, that it left an impression capable of holding half a gallon of water. The bird which left these hollows must have been four or five times larger than an African ostrich, and therefore could not have weighed less than six hundred

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* Saurians. † Chelonians. ‡ Batrachians.

Feet marks of Birds on slabs of Red Sandstone, with Rain Drops.

pounds. As it moved on, the sub-strata must have bent beneath the enormous load. An ox, walking over stiffened clay, would not have sank so deeply as did this tremendous bird.*

No bones of these huge birds have yet been discovered in the rocks of America, but enclosed in the same strata as that on which the feet marks are impressed, is a hardened manure, which, in its chemical qualities, exactly resembles the guano of sea fowl, now collected from the South American shores for agricultural purposes.

The vast amount of footsteps which the birds of the Triassic period have left on low, muddy shores subject to the return of the tide, is a proof that their habits were similar to the present ostriches of South America. Mr. Darwin† informs us, that the South American ostriches, although they live on vegetable matter, such as roots and grass, are repeatedly seen at Bahia Blanca on the coast of Buenos Ayres, coming down at low water to the extensive mud banks, which are then dry, for the sake of feeding on small fish. They readily take to the water, and have been seen at the Bay of San Blas, and at Port Valdez, in Patagonia, swimming from island to island. It is therefore evident, that in our times a South American mud bank might be trodden simultaneously by ostriches, alligators, tortoises and frogs, and the impressions left in the nineteenth century by the feet of these various tribes of animals, would not differ from each other more entirely, than do those attributed to birds, saurians, chelonians, and batrachians, in the rocks of Connecticut.

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* Slightly altered from Mantell. † Lyell's "Elements."

A few plants have been discovered in the layers of the Upper New Red Sandstones, most of which display a peculiar foliage, as much unlike the plants of the lower rocks as they are unlike those that lie over them.

In the middle of the Trias series, a compact greyish limestone, called the Muschelkalk, is found in Germany, but which has nowhere been seen in England. It abounds in fossils of saurian bones, numerous shells, and beautiful specimens of the lily encrinites. These beds denote a slow settlement of soil in the waters of a clear sea.

Vast deposits of solid rock salt,* together with strong brine springs, occurs in the upper Triassic group. (13) These salt beds are found in England, Hungary, Poland, Switzerland and elsewhere. They are supposed by some geologists to have been formed by the drying up of sea waters. Others having noticed, that wherever salt occurs, there gypsum (that is, lime mixed with sulphuric acid) is also found, have concluded that salt was originated during volcanic explosions, at the time that sulphureous exhalations, in the form of gaseous vapours were poured out. But neither of these explanations can sufficiently account for the formation of salt. Its origin is involved in mystery, and we can only thankfully accept it as one of the healthful gifts provided by a bountiful Providence, for the support of life. At Northwich, in Cheshire, two beds of salt lie (14) under a stratum of Red Sandstone, and run from ninety to one hundred feet in thickness, being almost unmixed with any earthy matter, although separated by a seam of clay. "A great deposition of salt may be traced, with little interruption, from the Black Sea to the Alps. It is very abundant in Spain. In Cardona in Catalonia, is a mountain of rock salt, about six hundred and sixty-three feet high above the surrounding soil, and about one thousand six hundred feet in circumference, but neither its depth, nor the rock upon which it rests, are discoverable. Some mines of rock salt are remarkably situated. At Poza, near Burgos, it takes the form of an immense crater, in which pumice stone and puzzuolanæ are found. Salt is not very common in Russia, nor in other northern countries, yet there are said to be two whole mountains composed of it in Astracan. It abounds in Persia, and the Isle of Ormus, in the Persian Gulph, almost wholly consists of rock salt. At no very distant period, a mountain of salt of an immense height, was discovered near the Missouri river, in America. This salt tract is eighty miles long and forty-five miles wide; the surface of which is barely covered with earth, and has neither tree nor shrub growing upon it.

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* Salt is made of the two gases, Chlorine and Hydrogen (termed together Muriatic Acid), blended with Soda.

On the other hand, many countries are almost wholly without salt. It is so scarce in the interior of Hindoostan, as to fetch two shillings and sixpence per pound, and it is said to pass as money both west of Thibet, and in Abyssinia.

The mines of rock salt in a branch of the Carpathian mountains, not far from Cracow, have been worked for five hundred years, and are said to extend more than three miles from east to west. The salt is generally of an iron grey colour, in which are found cubes of a pure white. Mr. Wraxall gives a striking idea of the appearance of this mine. He remarks, "After being let down by a rope two hundred and thirty feet, our conductors led us through galleries, which, for loftiness and breadth, seemed rather to resemble the avenues to some subterranean palace than passages cut in a mine. They were perfectly dry in every part, and terminated in two chapels, composed entirely of salt hewn out of the solid mass. The images which adorned the altars, as well as the pillars and ornaments, were all of the same transparent material; the points and spars of which reflecting the rays of light from the lamps which the guides held in their hands, produced an effect equally novel as beautiful. Descending lower into the earth, by means of ladders, I found myself in an immense hall, or cavern of salt, many hundred feet in length, breadth, and dimensions; the floor and sides of which were cut with exact regularity. One thousand persons might dine in it without inconvenience, and the eye in vain attempts to define or trace its limits. Nothing could be more sublime than this vast subterranean apartment, illuminated with flambeaux, which faintly discovered its prodigious magnitude, and left the imagination at liberty to enlarge it indefinitely."*

Our next chapter enters upon a new scene of rocky depositions, which are the commencement of a vast series of Limestone Rocks, intermixed with Sandstones and Clays.

QUESTIONS.

What settlement is found over the Magnesian Limestone?	(1)
What name is given to the clays and marls of the Upper New Red Sandstone series?	(2)
What mineral deposit is found in the Upper New Red Sandstone?	(4)
What peculiar marks are stamped on the layers of the Trias series?	(3)
Where did all the fine coloured muds of this series come from?	(5)
By what are the green colours of this group given?	(6)
What causes the various changes found in sedimentary strata?	(7)
What fossil wood has been found in the layers of this series in Warwickshire?	(8)
What marks are found stamped on the layers of this group?	(9)
What huge animal is believed to have left its foot prints on these sands?	(10)
What animal in North America?	(12)
What depth of rock contains these feet marks?	(11)
In what countries are salt beds found?	(13)
Upon what rock in Cheshire does the salt rest?	(14)

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* Extract from "New Library of Useful Knowledge."

THIRD DIVISION.

SECONDARY ROCKS.

CHAPTER 16.

THE LIAS.

(1) The Lias formation consists of blue and grey marbles, clay slates, and limestones. These strata were formed under the sea, and are full of shells, crinoidea, crustaceans, fishes, and extinct reptiles; accompanied with delta beds, containing half formed coal, the trunks and leaves of cone bearing trees,* and of plants allied to palms and ferns.

The name of Lias arose from the provincial mode of sounding the word layers; the lowest strata of these limestones being generally flat, and easily raised in slabs from the quarry.

The Lias formation varies in Europe, (2) from five hundred to one thousand feet in depth. Its upper beds are composed of numerous seams of clay, resting between deep piles of fine shales; these shales often contain much pyrites (a mixture of sulphur and iron), and as the pyrites settles upon the fossils enclosed in its shales, it gives them a golden burnished appearance. Some Lias shales contain bitumen—a mineral pitch that easily takes fire. When large masses of these shales become moistened on the sea shore, they often ignite of themselves, and burn on for years. Heavy rains have produced this effect both at Lyme Regis and at Weymouth in Dorsetshire. At Whitby in Yorkshire, in order to separate the sulphur from the iron in the pyrites, faggots are heaped on the shale, which is then left slowly to consume. During this process the sulphur quits the iron, and uniting itself to the oxygen in the air, and to the alumine in the shale, forms (3) a sulphate of alum, which is an article of commerce.

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* Such as the Larch and Pine.

The purest Lias limestones contain, in every hundred weight of the rock, eighty or ninety parts of carbonate of lime, the remaining ten or twenty parts being composed of bitumen, alumine, and iron. Limestones that abound in iron, form, when they are burnt, (4) a lime that readily sets under water, and to obtain this valuable article, the burning of Lias rocks has become a source of constant employ. The Lias formation is met with in Switzerland and on the eastern circle of France. (5) In England, the Lias extends in a waving line from Whitby in Yorkshire, to Lyme Regis in Dorsetshire. At both extremities it is fully developed, and presents similar features; namely, dark cliffs of blackish clay, or alum shale, with nearly flat blue Lias limestones, which extend into the sea, and form a natural pavement on which the observer may walk secure, treading at almost every step on the organic remains of the inhabitants of a former world, dissemminated through the rock.

Fossils are numerous in the Lias. The bed of the sea during its muddy deposition, possessed no great vasiety of corals, but was strewed with ⁽⁶⁾ crinoidea, or stone lilies, such as the pentacrinite; five species of which plant-like animal have been found in the rocks at Lyme Regis. ⁽⁷⁾ Several species of shells were numerous, particularly a species of oyster, called the gryphæa incurva. In some parts of the continent this shell so abounded, that whole beds, cemented together by a limy paste, form a marble called the 'calcaire à gryphites,' Many different sized univalve mollusks, having their organs placed around the head,* such as the ammonite and nautilus families,† swarmed in the Lias seas. The smaller species of ammonites, frequently lie in its rocks as thick as grains of corn on a barn floor. ⁽⁸⁾ Numerous fishes, of forms no longer found in our seas, glided amongst the ocean billows of that period, some of which were like the noble silurian fishes, and belonged to the family of the placoids having broad enamelled armour; others belonged to the ganoid families, which had square and often prickly bone scales, both orders being devoid of internal hard bones, yet possessing as high an internal organization as the most finished of reptiles.

Gryphæa incurva.

These fishes had, for countless ages, held a prominent place in the empire of the waters. During the period of the New Red Sandstone formation, they had diminished both in size and numbers, but again rose to some importance during the formation of the Lias and a few of the succeeding rocks; after which they almost disappear, and are replaced in the Tertiary rocks by fishes of less perfect forms. In this instance, as in many others, a kind of retrograde or going back from complex to simpler, may be said to have taken place, or in other words, as time went on, no advance took place in the perfection of form in one particular order of animals, by adding improvements to a first imperfect state; but actually a substraction is perceptible from the more perfect form, so as to reduce it to an inferior state. This change, as before remarked, is seen in fishes when reptiles advanced; and as quadrupeds advanced, reptiles are found to have diminished in size and in power. And finally when the time for the reign of man on Earth approached, the immense size of quadrupeds declined.

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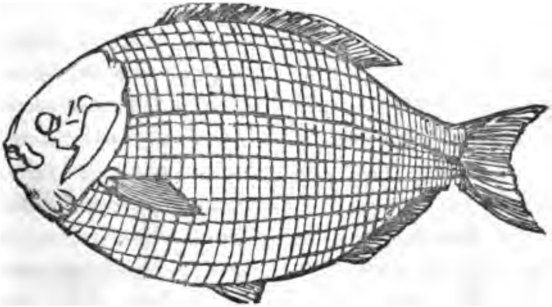
* Called the Cephalopoda tribe, or head-feet tribe.

† See picture of Ammonite in page 73.

Who, but an all wise and self-existing Being, the one only Creator, could have calculated upon the changes about to take place on the Earth, and so to have caused each range of animal life, to bear harmoniously upon the gradual introduction of higher orders of living beings?

Besides the bony plated cartilaginous fishes, various smaller kinds are met with in the Lias formation, having horny scales and internal bones. One singular species of fish abounded, that has peculiarly attracted the attention of naturalists, since it possessed some of the peculiarities belonging to the ancient families, united to the form of our present races. (9) This fish is called the Dapedius. It is of the ganoid* order, its body is thick and of an oval form, almost like a large plaice, and is covered with square scales of polished bone; yet unlike all other fishes in the lower rocks, the back bone of the Dapedius stops at the end of the tail, and leaves it to divide into two equal lobes, like our living races.



Restored figure of the Dapedius, of the Lias.

The first layer that separates the Lias formation from the marls of the Trias group, is a detritus of sand and mud, commonly called the bone bed; receiving this name from the immense quantities of water-worn bones, of teeth, and the remains of the inside of fishes, called *coprolites,* which it contains. This bone bed is found in Germany, and at Aust

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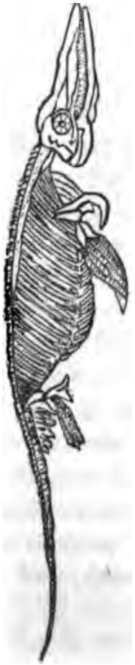
* For Ganoid see page 149.

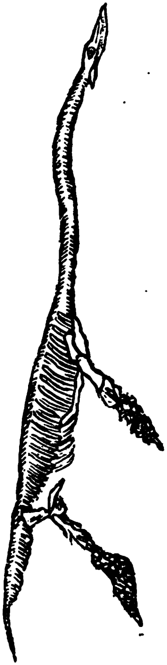
Cliff, on the Severn, near Westbury. Its seams of clay also contain fossil insects, belonging to the beetle and dragon fly families.

But of all the animal remains entombed in the Lias, the numerous and gigantic lizards, of which the African and eastern crocodiles are but poor and imperfect representatives, form the most striking objects of notice. Many varieties of these

Wing from the Lower Lias.



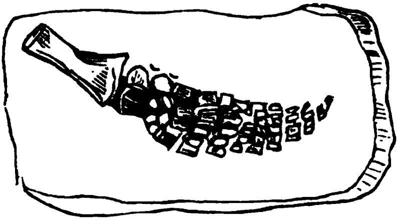
Skeleton of Ich-thy-o-saurus, or Fish Lizard.



Skeleton of Ple-si-o-saurus.

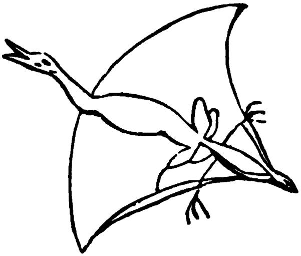
creatures existed, varying in length from a few feet to thirty in length. Some of these enormous lizards partly resembled a fish, and are therefore called the (10) Ichthy-o-saurus, or fish lizard. Others more nearly resembled land lizards, and are called the Ple-si-o-saurus; whilst others, called the Pte-ro-dac-tyles, possessed a wide membrane or thick skin, that was spread over bones, forming an organ not unlike the wing of a bat. Many of these lizards lived in the sea, others divided their time between sailing on the waters and creeping over the land; others ranged in woods and jungles, clothed with eastern vegetation, or basked on the margin of estuaries, lakes, and rivers. Even the air was tenanted by flying reptiles, under the dragon form of bat lizards. These creatures were the ruling powers on Earth, which at that time was probably too much covered with water, and those portions of land which had emerged above the surface, were too frequently agitated by earthquakes, inundations, and atmospheric irregularities, to be extensively occupied by any higher order than reptiles. The highest order of back-boned animals breathe by drawing air into the lungs, by which means the whole mass of the moving blood imbibes its oxygen; but in reptiles, the heart sends only a small portion of its blood to the lungs. On this account the blood of reptiles imbibes but little oxygen, and they remain cold animals. The muscles and nerves of such creatures are, therefore, little sensitive to change, which enables them to exist with naked skins, unprotected by any covering of hair, wool, or feathers. They dive with facility, and can remain long under water. Some reptiles bring forth their young alive, others lay eggs on sand and mud banks. Some are very active in their habits, others are torpid, and sleep during cold, dry, and very wet weather. They are dormant when nature does not need their help to keep the living world in controul, but rouse into activity during an increase of the animals and vegetables which constitute their food. Creatures possessing such a condition of life, were therefore well adapted for the stormy, changing periods of the world's early history.

Of all the varieties of reptiles found in the Secondary rocks, the Ich-thy-o-saurus, or fish lizard, and the Ple-si-o-saurus, more of a land lizard, have been the most accurately examined. The fish lizard appears to have possessed contrivances now dispersed throughout various classes and orders of existing animals. It had the snout of a tortoise, the teeth of a crocodile, the head of a lizard, the paddles of a whale, the back bone of a fish. Its stomach was large, its eyes of enormous magnitude, often exceeding the size of a man's head. Each eye was encircled by a series of thin bony plates, forming hoops around it such as the golden eagle possesses. This apparatus beautifully guarded the soft parts of the eye from danger, and afforded the huge monster protection from the light, when its head was lifted above the waters to take in breath. With this enormous eye, the Ich-thy-o-saurus could descry its prey at great distances. Its fore, paddles were large, and were composed of about one hundred bones, set out in five lengths or rows like the human fingers, but all enclosed in an outer membrane or skin. The two hinder paddles were smaller, containing about thirty or forty bones. The fish lizard must have plunged into deep waters, and have swum with prodigious velocity; and by the scales, bones and teeth, found in its stomach, we find that it chiefly lived with voracious appetite upon fish. Ten species of the Ich-thy-o-saurus have been discovered. The flat stony pavement of the Lias limestones, running into the sea at Lyme Regis, has been the grand store house from which Miss Anning obtained the skeletons of many of these monster reptiles. The Ple-si-o-saurus lizard appears to have frequented shallow waters near the shore, and to have floated like a swan. It had the head of a small lizard, the teeth of a crocodile, and a neck of enormous length. Living reptiles have from three to eight joints in the neck, but the neck of the Ple-si-o-saurus was composed of thirty-three joints, almost like the body of a serpent. The back and tail,



Fore Paddle of the Ple-si-o-saurus.

which latter was apparently used as a rudder, were formed something like those of quadrupeds. It had the ribs of a chameleon, and its paddles resembled those of a whale. After interment for thousands of years, and amidst the wreck of millions of extinct inhabitants of the ancient world, Geology has at length recalled to light ten species of these singular creatures, as well as several species of the flying lizards, called the Pte-ro-dac-tyles, the long projecting bones from whose sides, being covered by a thick membrane or skin, served for wings. "Most of the Pte-ro-dac-styles had the nose elongated, like the snout of a crocodile, and were armed with conical teeth. Their eyes were of enormous size, apparently to enable them to fly by night. From their wings, projected fingers terminated by long hooks, like the curved claw in the thumb of a bat. These hooks must have formed a powerful claw, with which the animal was enabled to creep or climb, or to suspend itself from trees. The size and form of the foot, and also of the leg, shew they had also the power of standing firmly on the ground, where, with their wings folded, they possibly moved after the manner of birds. They could also perch on trees and climb on rocks and cliffs with their hind



Pte-ro-dac-tyle.

and fore feet conjointly, like bats and lizards.* These flying lizards are believed to have lived much on insects.

In the Lias rocks, the stony skeletons of these various reptiles, from the nose to the last vertebra of the tail have been preserved entire. This perfect arrangement of the skeleton, with the fact, that in the stomachs of many of these voracious reptiles are found the scales, bones and teeth of the fish they had recently eaten, is a strong proof they were suddenly killed, and then quickly enveloped in mud by an outburst of volcanic lime under the waters. It is supposed that the ocean in which these saurians lived was liable to sudden and frequent changes, and the varied nature of the Lias beds justifies this belief. Their strata are repeatedly changing from limy to sandy, and from sandy to clayey beds, the clay usually forming the under strata of each series. These alterations are accounted for by the supposition that, during certain periods, the sea threw down deposits of clay or mud, and then, changes in the currents, the washing down of cliffs, and various volcanic discharges, again produced new beds.

The waters, during all these changes, literally swarmed with animals belonging to genera and species, most of which became extinct before the Tertiary rocks were formed. (11)Besides the saurian animals, shells and pentacrinites, star fishes, crabs, bones and plates of the turtle, with whole families of cuttle fishes, called the Loligo, are found buried in the Lias

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* Buckland.

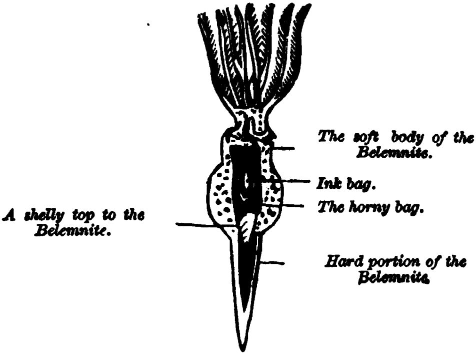
Cuttle Fish.

These last singularly formed creatures, the Loligoes, possessed a bladder, or bag of ink in the inside of their bodies, with which they could darken the waters when alarmed. Many of their bags, in a fossil condition, still hold the sepia ink in a dried state, which on trial has been found superior in quality to the sepia ink of the living cuttle fishes. The frail skin of these ancient loligoes' bags has, no doubt, been thus wonderfully preserved for thousands and tens of thousands of years, by their sudden and rapid enclosure in the Lias mud.

The singular families of the Belemnites, of which eighty-eight species have been discovered, appear to have swarmed in the waters of the Secondary rocks. The frame-work of the body in this family was formed of three distinct parts. First, a long thin chambered shell, which was enclosed in a hollow sheath of shelly substance, that tapered like a cone. This sheath, in its fossil state, is often termed a thunder bolt. The sheath, with its chambered inside, was again enclosed in a horny bag, that rose some height above the hollow cone, and contained in its higher parts a bag of sepia ink, together with the body and arms of the animal.

The immense size of some of these belemnites may be imagined, from their fossil ink bags sometimes measuring nearly one foot in length.

Belemnite Cone.


A shelly top to the Belemnite.
The soft body of the Belemnite.
Ink bag.
The horny bag.
Hard portion of the Belemnite.

Thus we learn from the fossils deposited in the various rocky strata of the Earth, that life has long abounded. That the types of the *Radiated*, the *Articulated*, the *Molluscous*, and the *Vertebrated* divisions of animals have, from the dawn of the first creation, been closely preserved, although each division has been subject to immense variety in the forms of the individuals representing it; each variety being adapted with an exquisite propriety to suit the existing state of the land and water.

Geology thus reveals the mighty fact, that the world existed in a solid condition for countless ages before the creation of man; and that during those ages, its many rocky soils had been peopled by a succession of animals, possessing peculiarities distinct from our present creatures. By these facts we gather, that between the first and second verses of Genesis, must lie an immense and unrecorded lapse of time! For, after the "*beginning*," mentioned in the first verse, no record is given of the Earth's history, until it was fitted in its soil for the residence of man.

The study of Geology, whilst it points as a way-mark to the past eternity of God, humbles the pride of man, correcting his arrogant supposition that all creatures from the first were made for his own benefit and enjoyment. And by the beautiful adaptation which we find in each ancient creature for its peculiar mode of life, our adoration and praise are called forth at the manifold wisdom of God, "for whose pleasure they are, and were created."

QUESTIONS.

Of what do Lias rocks consist?	(1)
What depth do the Lias rocks average?	(2)
What two articles of commerce are drawn from the Lias rocks?	(3), (4)
In what direction does the Lias extend through England?	(5)
What three remarkable species of reptiles are found in the Lias limestone?	(10)
What other fossils prevail in the Lias?	(6), (7), (8), (11)
What fish is peculiarly remarkable in the Lias formation?	(9)

THIRD DIVISION.

SECONDARY ROCKS.

CHAPTER 17.

OOLITIC GROUP.

CALLED BY THE FRENCH "TERRAINS JURRASSIC."

(1) The Oolitic group rests on the Lias, and is a diversified series of yellowish limestones, sandstones, grits, and clays, replete with corals, shells, fishes, reptiles, some mammalia,[*] and plants. This group of rocks is divided into three formations :—

THE UPPER OOLITE	Portland Stone. Kimmeridge Clay.
THE MIDDLE OOLITE............	Coral Rag. Oxford Clay.
THE LOWER OOLITE	Corn Brash, and Forest Marble. Great Oolite. Stonesfield Slate. Fullers' Earth. Inferior Oolite.

(2) Oolitic rocks are met with in Scotland, and can be traced through the centre of England, from the eastern shores of Yorkshire down into Dorsetshire. (3) They form numerous beds of yellowish limestones, divided by layers of clays, marls, and sand, and (4) are distinguished from each other by their peculiar organic remains. In France, and in the Jura mountains, these rocks are grandly developed, forming bold decli-

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[*] Mammalia—animals that suckle their young.

vities in consequence of the clays being washed away, which once filled up the vallies that now lie between Oolites and the harder limestones.*

(5) The name of Oolite is derived from the Greek words, *oon* egg, and *lithos* stone, and has been applied to this rock, in consequence of its limestones being frequently composed of numerous small egg-like grains that resemble the roe of a fish. The centre of each of these grains is usually a minute fragment of sand or pounded shell, around which the limy mud has settled in concentric layers.

(6) The Oolitic strata in Germany,† contains the fine marly slates that are used for lithographic drawings. Many of these slates are celebrated for the beauty of their fossils, the extremely fine sediment of which they are composed having preserved the most delicate impressions of the most tender parts of plants and animals. Count Munster had collected from these slates, in 1833, two hundred and thirty-seven species of fossils, among which were seven species of flying lizards, six of saurians, three of tortoises, sixty-six species of fish, forty-six of crustaceans and twenty-six of insects. These insects, amongst which is a large species of dragon fly, must have been blown out to sea, and have fallen under the waters then rolling over Europe, having probably come from the same land to which the flying lizard belonged.

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* The Great Western Railway which runs from London to Bath, and the North Western line running from the Euston-square Station to Derby, pass through much of the Oolite system. Farringdon, Chippenden, Colne, &c., exhibit good sections of its deposits.

† In Bavaria.

We have already observed that the shells, found in the lowest rocks, were adapted to live in deep waters; they consisted of bivalve or two-lidded shells, whose inhabitants have neither heads nor eyes, and of internally chambered shells, such as the orthocera, ammonite, nautilite and belemnite families, whose mollusks could ascend or descend amidst the billows as they pleased. But unchambered univalve shells are rarely found amongst the lower rocks; whilst in the Oolitic range the genera and species of univalve shells become more numerous, and individual shells of many species abound. As these univalve mollusks had heads and eyes and crept by a flat disk on their bodies, Mr. Bakewell says, "we may infer that they did not reside in deep seas, where the sense of vision could not be available, but lived and moved in comparatively shallow waters near the shore." (7) By such striking facts we gather, that during the whole time in which the Oolitic rocks were accumulating to the depth of one thousand feet or more, vast portions of the crust of the Earth were retained near the surface of the waters. To admit therefore of this depth of rock being piled over the Lias, a lowering movement in the internal parts of the globe, must have been constantly going on, causing its crust, as the layers thickened, to sink down by insensible degrees until the formation was completed. And in confirmation of this fact we find, that each layer in the Oolitic group displays when split open, that it once lay near the surface of the waters, and was the scene of an immense amount of animated existence.

(8) The lowest, or Inferior Oolites, are ripple marked slabs of brown limestone, spread over beds of yellow sand, that covered the Lias clays. These slabs are often used in the north of Britain for roofing slates. The laminæ, or leaves of these calcareous slabs, are frequently furrowed, from having taken the form of the ribbed sands, upon which they had settled under under the water.

At Collyweston, in Northamptonshire, this stone betokens the neighbourhood of a sea-beach, having footsteps apparently of crabs impressed upon it, and enclosing in its layers fragments of crab-claws and of broken shells.

(9) *Fullers' Earth.*—Masses of a soft clay, called Fullers' earth, often lie upon the coarse slates of the Inferior Oolites.

(10) *Great Oolite.*—The Fullers' earth is succeeded by a series of rocks of great depth, called the Great Oolites, amongst whose strata lie the Bath building stones. Corals, starfishes, ammonites, nautilus, with bivalve and univalve shells abound in this series. The few univalve shells found in the lower rocks had round mouths, an almost sure mark of their having been sea weed or vegetable feeders; but in the Oolites a great change is apparent in the character of the univalves. Forty-one species of those shells having been found with a notch at the end of the shell, through which the mollusks inhabiting them, thrust out their rasping boring tongues, thus marking them, as usually carniverous feeders.

(11) *Stonesfield Slates.*—This portion of the Great Oolite forms one of its lowest beds, and is a collection of round limestone masses embedded in sand. The Stonesfield slate is not above six feet thick, but its balls of limestone are full of organic remains, that largely display the once animated population of the Oolitic world. (12) Various wing cases of beetles, with the relics of other insects are met with, all probably carried down by rivers into the sea where the Oolites were forming, and are mingled together amidst shells, shrimps, prawns, lobsters, crabs, and many kinds of fishes. Traces of reeds and grasses, of palm trees and ferns are found in connection with the legs of birds, and the bones and teeth of gigantic land lizards. From the size of the lizard bones, it is estimated that some of the reptiles must have measured forty feet in length, and twelve in height.

Strange scenes do these saurian bones open to the view of the mind's eye. The Pte-ro-dac-tyles, by their forms and habits were qualified to move by night and by day—to fly, swim, or creep; fit companions for their kindred reptiles that swarmed in the seas and crawled on the shores of our turbulent planet. With flocks of such kinds of creatures flying in the air, with shoals of no less monstrous Ich-thy-o-sauri and of Ple-si-o-sauri swarming in the ocean and gigantic crocodiles and tortoises crawling on the shores of lakes and rivers; both air, sea, and land, must have been curiously tenanted in these early periods of our infant world. Yet, wonderful as these relics are, the Stonesfield slates contain the bones of two other animals, that offer to the Geologist still more interesting subjects of thought than the saurian bones. One of these sets of bones appears to have belonged to a small insect-eating quadruped and the other to a vertebrated animal of the oppossum, or pouched families. Six specimens of the lower jaws of these creatures set with teeth, have been seen, and form the only instances yet discovered of the existence of warm blooded animals (the birds of the Trias excepted), during the creation of the lower and middle ranges of rocks. The under jaw of the insect-eater is long and is furnished with thirty-two teeth.

(13) *Forest Marble.*—Upon the deep soils of calcareous earths that form the great Oolite, thick forests of encrinites or stone lily animals, sprung up in the clear tranquil waters that covered the lime. These creatures flourished in great numbers over some parts of Wiltshire, until a current of blue lime rolling over them, broke their stems, scattered their fragments, and formed a new deposit, which by pressure and other causes acting upon the carbonic acid in the lime, caused this deposit to crystalise and form a marble called the Forest marble, the appearance of which is greatly ornamented by the broken encrinites it contains.

(14) *Oxford Clay.*—Deep beds of blue clay settled upon the Forest marble, in some places to the depth of five hundred feet. These beds have received the name of Oxford clay. They contain but few corals, but display many ammonites, other shells and various

fossil remains, the most remarkable of which are the soft parts of many cuttle fishes. The stiff pale blue argillaceous beds of the Oxford clay are spread over a great part of England, more especially over the fen districts in Cambridgeshire and Lincolnshire, producing a wide expanse of flat undrained country. This clay can be well seen at Weymouth, in Dorsetshire, in Oxfordshire, and in the East Riding of Yorkshire.

(15) *Coral Rag.*—Upon the surface of the Oxford clay, rose extensive reefs of corals and madrepores, which reefs may be traced from Wiltshire,* through England, up to the right bank of the Humber in Yorkshire. At the time these corals lived, the sea flowing over England must have been shallow, and probably many portions of its lands were raised up in separate islands in the open sea. As the corals grew, the openings between their stems and branches formed receptacles for shells, sand, and pebbles, and at length streams of limy mud and siliceous deposits flowing over them, the whole mass became one consolidated collection of rock. In Wiltshire, Berkshire, and Gloucestershire this Coral Rag is extremely rich in fossils.

(16) *Kimmeridge Clay.*—Some change in the currents of the waters, as well as in the state of the neighbouring lands, covered many parts of the Coral

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* In Wiltshire, around the neighbourhood of Colne, and Steeple Ashton, the Coral Rag is found in the greatest abundance, and in beds forty feet thick.

Rag with bituminous marl, which settled in thin separate layers over the bottom of the sea. This clay is sometimes three hundred feet thick and is called Kimmeridge clay, from its being burnt as fuel in the neighbourhood of Kimmeridge in Dorsetshire.

(17) *Portland Stone.*—Upon the bituminous clay shales, settled a vast deposit of white lime, forming a mass of stone fifty and eighty feet thick, called the Portland stone. Some of the strata in this stone abound with fossils. Large ammonites, trigonia, pectens, oysters, pinnæ, terebratula, turritella, &c., with bones of saurians and drifted coniferous wood, are amongst the prevailing organic remains of the deposit. Portland stone is quarried in large quantities in the Island of Portland, and is well known throughout England as a fine building material. St. Paul's Cathedral in London, many bridges and other public edifices are built with its stones.

We now pass on to a set of fresh-water formations, which partially covered the Oolitic group.

QUESTIONS.

What rocks rest upon the Lias? .... (1)

Where can we trace in the British Islands the settlement of Oolitic rocks? .... (2)

Of what are the Oolitic rocks composed? .... (3)

How are the three ranges of Oolites distinguished from each other? .... (4)

From what is the name of Oolite derived? .... (5)

What is the fine marly Oolite strata in Germany used for? (6)

What lesson do we learn with regard to the Oolitic formation, by finding an increase of univalve shells in its strata? .... (7)

What are the lowest beds of Oolites like?.... .... (8)

What lies over the ripple marked slabs? .... (9)

What succeeds the Fullers' Earth? .... (10)

What remarkable Oolite slates follow next? .... (11)

What fossils are found in the Stonesfield Slates?............ (12)

What strata follows the Stonesfield Slates? .... (13)

What are the deep beds of blue clay that follow the Forest Marbles? .... (14)

What lies over the Oxford Clay? .... (15)

What lies over the Coral Rag? .... (16)

Name the building stone that closes the Oolitic range?... (17)

THIRD DIVISION.

SECONDARY ROCKS.

CHAPTER 18.

THE WEALDEN GROUP.

(1) THE Wealden group is a fresh-water collection of sandstones and gritstones, of conglomerates, argillaceous limestones, and slaty marls. The whole group is supposed to rest upon the Portland Oolites. Sir Charles Lyell has divided this group into three beds. The uppermost layer is :—

First,—The Weald clay, including beds of sand and shelly limestones.

Second,—The Hastings sands, in which occur some clays and calcareous grit.

Third,—The Purbeck beds, consisting of various kinds of limestones and marl.

In pages 8 and 9, allusion has been made to the vast amount of drifted trees, sand and mud brought down to the sea by the mighty waters of the Mississippi and Ganges. The detritus of these rivers being thrown upon the bed of the ocean, forms at their mouths extensive tracks of muddy lands, termed deltas. Layers of delta mud are usually strewed over with pebbles, and with the vegetable and animal substances engulphed in the river stream during its onward passage. Should the land of such a delta be sunk beneath the sea waters, and become pressed and hardened into a solid slate, it would, on the waters being directed into another channel, become dry land and form a site upon which towns and villages might be built. In digging foundations for the houses and in making wells, the plants, shells and bones strewed over the once muddy layers of the delta, would then of course be thrown out and exposed to view.

Had a man lived so long as to remember having seen these fragments carried by river transport into the former delta, he would be no more surprised at finding such remains thrown out, than a botanist would be surprised at finding his plants secure between the leaves of his drying books. But a stranger who had never seen such materials thrown upon a watery waste, nor ever reflected upon the variety of substances that fall into the beds of rivers, lakes, and ponds, would doubtless be astonished at beholding the leaves of plants and delicate shells in the midst of stony layers. Should he, however, declare these beautiful objects were no organic substances, but only changes in the rock, which had accidentally taken the form of leaves and shells, he would shew his ignorance of a great and interesting subject.

(2) A series of muddy deposits brought down by rivers, is therefore a clear and simple explanation of many rocky phenomena. Yet, Geologists were much surprised a few years ago, at discovering in the south of England, in France, and in Germany, a range of rocks resting upon the sea-formed Oolites, full of fresh-water fossils, and to find that these fresh-water rocks were again covered over by the sea-formed chalk.

The question arose, how could these fresh-water groups have been deposited between two sets of sea rocks, the one beneath them, the other above them?

As the Bible does not explain the Creator's mode of working out his arrangements of the rocky crusts of the earth, we can only gain information upon this point, by remarking the present operations going forward in nature. Let us then turn to the present deltas of the Ganges and of the Mississippi, and we shall see a work in progress, capable of producing beds of rock similar to those found in the Wealden group. The streams of the Mississippi and of the Ganges, are thick with sand, lime, and clay, and pour yearly into the ocean thousands and millions of tons weight of soil, intermixed with the skeletons of crocodiles, rhinoceroses, lions and whatever kinds of animal and vegetable substances may have fallen into their waters. (3) Now should a range of sand banks, or a reef of rocks be stretched around each of their deltas, so as to keep out the sea water, the space within would soon become one vast fresh-water lake, into which the river settlements would be poured.

Under these circumstances it appears, that the Wealden beds were formed. And by the substances they contain, we gather that the ridges of sand or rock, which hemmed in the Wealden delta, must have stretched across an area two hundred and twenty miles in length, and two hundred in breadth, enclosing the Isle of Wight, Sussex, Kent, and Surrey, also the bed of the English channel, with parts of France and Germany.

In the sand, lime and clay that settled over the bed of this delta (from the depth of one hundred to nearly two thousand feet,) fifty-two species of land and fresh-water animals, with nine species of plants, have been discovered. Amongst these a few marine shells occur, teaching us that the sea occasionally broke over the banks of the delta, or gained admittance by an estuary.

Such a delta of sand, clay and mud, as the Wealden rocks denote, must have been supplied by large rivers, capable of bringing down prodigious masses of soil from off the surfaces of some vast continents. Again we would ask, from what lands did such extensive rivers flow? Surely the Wealden rocks disclose the great fact, that the Creator had seen it good to raise up continents in the very quarters, where the billows of the Atlantic and Pacific oceans now roll; which lands, by their contributions of mud and sand, worked out His high behest, in preparing ground suitable to form a temporary residence for immortal and intellectual creatures.

The first deposit of mud thrown down by these unknown rivers upon the Wealden delta, appears to have been a thin stratum of dark shales that settled upon the Portland Oolites. (4) Portions of the Oolitic rocks, after being covered with this shale, seem to have been heaved up, and to have formed islands in the watery waste; (5) which islands were eventually overspread with forest plants, such as now grow in tropical climes. At length these fruitful islands appear to have sunk beneath the waters, but so tranquilly, that the vegetable mould around the trees, together with pebbles from the neighbouring rocks, were not even washed away from their roots. The land merely sunk down, and became buried under beds of limy mud, intermixed with sand and clay that overflowed the delta. A few shells which are able to live both in salt and brackish waters, such as the oyster families, are found in the first layers of this limy mud; then follow the bones of fresh-water fish and a great abundance and variety of river shells. The most numerous of which are the Paludina.

Paludina Shell, two sizes.

(6) In Dorsetshire, this settlement of lime and enclosed shells became closely pressed and altered into stone, which from its beauty, has been called marble; and in consequence of its strata being exposed to view on the sea cliffs at Purbeck, it is been given the name of Purbeck marble. This marble is employed in architecture, and has been much used in forming columns for our finest cathedrals.

After the deposition of the Purbeck marbles, a fresh change took place in the level of the English part of the delta. Island patches of the newly formed limestones appear to have been lifted above the waters, forming a kind of archipelago, upon whose islands flourished large forests of pine and fern plants, forming the homes of various reptiles, turtles and other animals. How long these fruitful islands continued to exist cannot be known, but that they stood above the waters for a very considerable period is attested, by the number and magnitude of the petrified trees which are still to be seen in the districts where those islands arose. Some of their stumps, shivered as if broken off by hurricanes, are still rooted in the Isle of Portland in Dorsetshire, in the very shale or dirt bed as the workmen call it, in which they grew; their shattered stumps being traced far out into the sea in the English channel. They generally rest in a sloping direction, in consequence of the after upheaving of the strata, just as pegs fastened into a plank of wood, would slant downwards, on one end of the wood being considerably raised above the ground.

(7) The level of the delta for a third time being altered; the forest islands sank beneath the waters, and fresh layers of lime, divided by seams of sand and clay were deposited over them. (8) After this settlement of lime an important change took place in the nature of the soil brought down by the rivers; the delta became overspread with sand, which accumulated in places to the depth of four hundred and five hundred feet. The white rock of Hastings is composed of this sand. The Hastings sand, or middle group of the Wealden, also contains beds of brown and blue clays, shales and limy grit, enclosing fossils of carbonized wood, and the bones of reptiles and of fish.

"Every dirt bed may no doubt, be the memorial of many thousand years or centuries, because we find vegetable soil is long in accumulating, and that two or three feet of earth is the sole monument, which any present tropical forest has left of its existence, since the ground on which it now stands was first covered with its shade."—*Lyell.*

(9) The third or top stratum of the Wealden delta is called the *Weald clay.* This clay is entirely of fresh-water origin, and contains the bones of most wonderful reptiles.

The rivers that threw down upon the Wealden delta the sand, lime and clay they had gathered from vast continents, must not only have been of immense size, but they must have been pouring down their waters for incalculable periods of time. The Ganges, as we have before remarked, has for centuries thrown into the Indian ocean vast weights of mud, yet it is calculated, that were its delta to be now lifted up, it would not yield a rock above one hundred feet in thickness, whilst the Wealden beds in some districts, are nearly two thousand feet deep.

This great depth of soil by no means however convinces us, that the Wealden delta itself was deep; it seems probable, (10) from the nature of some of the embedded fossils, that many of the Wealden rocks were formed out of the deposits originally settled in very shallow waters. In some places, vegetables that belong to marshy grounds, or that only grow on mud that is occasionally laid dry, are standing erect in the midst of reddish sandstones, as if the sand had been gently deposited around them on the very spots where they grew.* Yet the estuary or bay in which they flourished never however quite filled up, because as gently as new deposits of mud and sand kept raising the bottom of the bay one foot higher, so the ground kept constantly sinking one foot lower from the surface, by a gradual depression of the crust of the Earth.

(11) Other imbedded fossils again betoken deep waters and many bear the stamp of having passed through a long line of river transport. The stems of the trees are rubbed and water worn—the branches are stripped of their leaves—the edges of the stones are rounded—the bones of animals smoothed, as if long beaten about in moving waters—the teeth of animals are detached from their sockets, and the bones of the back disjointed and scattered hither and thither. Yet upon these very fossils, sufficient traces are left to teach geologists that the land from which they came was a country full of hills and dales, watered by large streams. A land enjoying a higher degree of warmth than our present England—one clothed with delicate groves and dark forests of palm plants, lofty ferns and cone bearing trees; whilst its low lands were covered with rich pastures of delicate ferns and equisitæ.

This land of streams and of eastern foliage abounded in life. Immense birds, huge reptiles, turtles, and land tortoises basked on the banks of its fens, lakes, and rivers; and its streams abounded with fish, fresh-water shells and crustacea. As these animals died, many of their remains sank in the rivers, and were hurried forward into the general delta. The bones, teeth, and scales, (12) of at least five species of gigantic lizards have been ascertained. And by the elevation of France, Germany, and England into dry land, the fossils of that ancient life, concealed in their rocky strata for thousands and most likely for millions of years, have again come to light, revealing a scene of once animated existence, unlike the living creatures now moving on the face of our Earth.

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* Such plants are found in the sandstones at Fitton, near Tunbridge Wells.

From the nature of the lizard bones found in the Wealden beds, it is clear that some of its saurians lived on land, and that others lived in water, and resembled the Icthyosaurus and Plesiosaurus of the Lias and Oolitic rocks. The largest bones in the arms and legs of swimming saurians were solid throughout, but the back bones were made rounding or hollowed like a fishes vertebræ. The bones of several species of such water lizards having been found in the Wealden beds, we gather that the rivers, creeks, and bays of its continents were thickly peopled by these reptiles, (13) the size of the bones leading us to suppose that many of them were forty or fifty feet in length, and in bulk equal to the size of the whale. They are believed to have had web feet and broad tails.

The large leg bones of three other species of huge lizards found in these beds are hollow, and appear to have had the cavity filled with the light material of marrow.

This round hollow form, combining strength with lightness, must have enabled the lizard to which they belonged, to move on land; and in accordance with these hollow bones, the same lizard had no arms to act as paddles, but had thick round feet like those of a rhinoceros capable of supporting a heavy body on dry land. The bodies of these Wealden land and water saurians are never met with entire. By floating long in water and being rolled backwards and forwards in the eddies of a river, before they sunk into the mud of the delta, each bone, tooth and scale has been separated, and is often found in a broken condition.

To collect the scattered fragments of these reptile skeletons—to sever them from the rocks—to re-unite them into a whole, and to place the bones side by side so that each one might belong to its respective animal, and yet not to confound the different species together,. was the hard labour which the intelligent collector of the Wealden saurians had to perform. And the perfect skill with which the first studiers of the Wealden beds completed their work, is now proved, by the singular circumstance of one of these huge lizards having been found in Sussex in a slab of sandstone, whose form perfectly matched the skeletons artificially arranged by the naturalist. The body of this reptile had probably been drifted into the sea then flowing over England, and on sinking into the depths of the ocean became buried in the soft sands accumulating on its bed.

This extraordinary relic was discovered in 1832, in a quarry in Tilgate Forest, imbedded in a block of sandstone, which also contained the remains of vegetables and several kinds of seed vessels. The stone had been broken up by the quarry-men, and a great part of it had been thrown upon the road, before it was suspected of containing anything at all interesting. The pieces that remained were carefully collected by Mr. Mantell, the Sussex Geologist, who placed the whole again together, and carefully chiselled away the sand which enveloped the bones. By this means great part of the skeleton of an ancient reptile was displayed, and now forms one of the most interesting specimens in Europe. The probable length of the creature was about twenty-five feet.

Three species of colossal crocodile lizards, formed to walk on dry land and now termed "the fearfully great lizards,*" appear to have roamed at large, the mighty possessors of the Wealden earth. The hind leg of one of these lizards, called Megalosaurus, measures nearly two yards long, and for the rest of its body to have been in proportion with this leg it must have been fifty feet in length. The roundness of its feet, and the hollowness of its bones, prove that it lived on land, whilst the form of its teeth prove that it was a carnivorous or flesh eating animal, being so constructed at their edges as to act like a knife, a sabre, and a saw.

The Megalosaurus probably lived upon small crocodiles and turtles, whose remains are found in great abundance in the same strata with its bones, and which no doubt were brought down by the same streams that rolled the Megalosaurus into the delta.

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* Dino-Saurians.

But of all the land reptiles placed on the Earth, the Iguanodon is the most wonderful. This saurian appears to have had a body like an elephant, to have been supported upon thick hind legs twelve feet in height, formed like those of a rhinoceros; to have had rounded feet, and a tail of such a length, that from the nose to the end of the tail, the creature must have measured ninety or one hundred feet in length. From the character of its teeth we find this huge Iguanodon was a harmless vegetable feeder. Its teeth are formed with curves, and have cavities and joints of elevation, which enabled them to act like powerful pincers in seizing hold of wood, and like strong nippers in tearing down and cutting through the branches.

During the middle periods of the Earth's formation, when but few warm blooded animals had been created, the important office of keeping the excessive growth of trees and water plants within due limits, appears to have been laid upon the lizard families, whose habits fitted them in a peculiar degree for such a service.*

In South America we have now living a small vegetable eating lizard called the Iguana, which is furnished with long slender toes, by which it is enabled to climb trees with great facility in search of food; but no tree could have borne the weight of the colossal Iguanodon lizard, accordingly the hind feet of the

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* The living species of the crocodile or lizard family are twelve in number:—one gaveal, eight true crocodiles, and three alligators

Iguanodon were not furnished with hooked claws, like the Iguana, but were made round and thick to support the animal, and ended with compressed claws like the land tortoise. But the fore arms being required to lay hold upon branches, had long slender flexible bones similar to the fingers of the Iguana, and were armed with curved claws, the exact counterpart of the nail bones of the living American Iguana.

The huge ancient Iguanodon being thus furnished with strong feet and a prehensile or holding instrument, could seize hold of and tear to pieces the palms and arborescent ferns which furnished it with food. Thus we see how beautifully and admirably the Lord God adapted the structure of this huge creature to meet the necessities of its life.

The Hylaisaurus was another lizard of the Wealden era of enormous dimensions, and was distinguished by a row of scaly fringes on its back, some of which were seventeen inches in length, and which when erected must have given the animal a truly terrific appearance.

(14) The Wealden beds, formed from the detritus of the continents that supported these huge lizards, contain also fishes of quite another character to those found in the chalk immediately over them. (15) And not one chambered shell, such as the nautilus, ammonite, and belemnite, which abound in all the other secondary rocks, has ever been met with in the Wealden formation, a fact decisive of the peculiar character of these extensive fresh-water beds.

QUESTIONS.

What fresh-water range of rocks rest upon the Oolites?... (1)
How were the Wealden rocks formed?.................... (2), (3)
Was any land seen in the Wealden delta?.................... (4)
What grew on these islands? .... (5)
Of what is the Purbeck marble made? .... (6)
After the islands were sunk what overspread the delta? (7), (8)
What is found deposited in the top strata of the Wealden clay?.. (9)
What does the condition of the Wealden fossils denote? (10), (11)
How many species of gigantic reptiles have been found in the Wealden beds?................................. (12)
What size do some of these reptiles appear to have been? (13)
What is remarked of the Wealden fish?..................... (14)
What proofs offer a decided mark that the Wealden beds were of fresh-water origin? .... (15)

THIRD DIVISION.

SECONDARY ROCKS.

CHAPTER 19.

THE CRETACEOUS, OR CHALK GROUP;

CONSISTING OF THREE DEPOSITS,

CHALK, CLAY, AND SANDSTONES.

The Wealden group of fresh-water rocks, which had been accumulating during incalculable periods of time, at length came to a close, and (1) the crust of the Earth gradually sinking, caused the whole of the Wealden group to be submerged or lowered under the waters. From this period the bed of the sea also, or those portions of the globe now forming Europe, Asia, Africa, and America, appear to have been continually descending, making way as it were foot by foot for (2) vast deposits of chalk, clay, and sand, which rest upon the Oolitic and Wealden beds, and are termed as a whole the *Cretaceous* or *Chalk group*.

The Cretaceous group varies in thickness from a few feet to (3) nearly two thousand in depth. (4) It contains scarcely one fresh-water fossil (a little drifted wood being the only exception), but it abounds in animalcules, sea weeds, marine shells, sponges, corals, sea urchins, belemnites, ammonites, nautilites, and the bones of some fishes and reptiles.

(5) The Cretaceous group may be divided into three parts :—

First—The Upper Chalk with flints, and the Lower Chalk without flints.

Second—A clay called the Gault, or Folkestone Marl.

(6) Third—Green Sand, which is divided into Upper Green Sand or Fire Stone, and Lower Green Sand or Shanklin.

The arrangement of these rocks varies in different countries. In the south of England chalk, clay, and sand are all three met with. In other parts the sand and clay are missing, and the chalk rests upon the Oolites and even upon the Lias.

The lowest beds of the Green sand lie in conformable layers upon the Wealden clay, that is, evenly upon its surface. (7) Green sand is composed of grains of fine flint and lime, mixed with pebbles of jasper, flinty slates, grains of mica, and chlorite or green earth, from whence the name of Green sand has arisen. This sand must have been derived from the crumbling particles of that ancient land, from whence the Wealden beds had received their river soil. Upon the sinking down of those lands much turmoil probably took place. And the grinding together of rocks of granite, gneiss, and slates, with the washing away of the soil that lay decomposed on their sides, appears to have overspread large districts of the ocean with dust, which sinking down formed the depth of Green sand which we find in some places four hundred feet in thickness.

In the midst of this settlement a change took place in the soil brought down, as (8) a stratum of blue clay and marl, called *Gault clay,* frequently divides the

Green sand into two beds. In the south of Sussex the Gault clay is one hundred and two hundred feet thick. It contains oyster shells, ammonites, nautilites, and a small species of belemnites, with other shells, which are generally remarkable for the brilliant pearly lustre of their surfaces.

In many places the Upper Green sand, or that which lies over the Gault clay, forms a hard sandstone, it is mixed with lime and green particles and is called Fire-stone. Bands of flinty limestone or chert also occur in this deposit. In other places the Green sand remains in loose particles. In all its slates it contains many shells and nodules of stone, which are formed of beautifully clear silex termed Chalcedony. These stones are abundantly found in the Green sand around Sidmouth in Devonshire.

When the sea water which held the sand and clay and lime of this group, had been cleared by the settlement of such materials into beds,* (9) a deluge of nearly pure lime or calcium, mixed with carbonic acid gas, overspread as with a delicate white sheet immense portions of the ancient beds of the seas. By some remarkable operation in nature, this influx of lime, termed Chalk, was extended in nearly one uniform aspect and state of composition, from the north of Ireland down into the Crimea in Russia, a length of one thousand four hundred miles, and from the the south of Sweden to the south of Europe eight hundred miles in breadth. In the south of Asia, and in many parts of America, we find by the appearance of the fossils peculiar to the Chalk formation, that a nearly equal flow of lime took place in those quarters of the globe.

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* There are two facts which shew that the waters had become clear before the Chalk lime was deposited. First, scarcely any sediment such as sand is met with in Chalk. And second, that upon the Chalk, corals soon began to build, which never live in thick water.

The question naturally arises, from whence came this vast amount of white powdery lime? This question no man can answer. Mr. Bakewell judiciously remarks, "I hold the Earth itself and its ancient atmosphere, to have been the great chemical laboratory, in which all the solid and fluid parts of the surface were originally prepared and formed." Chalk may therefore have arisen up and been spread forth by hot springs, like the Travertine limestones in Italy, or it may have been gently poured forth in lime streams from craters of volcanoes. Such a flow of chalky mud was seen in 1777, descending from the volcano of Motdawa in Sicily, and though it only flowed for the greater part of one day, yet it formed a bed of chalk several feet in depth. Had this limy eruption taken place under the waters, its earthy particles would have been more widely dispersed, and it would have enveloped in its white soil every fish, shell, and organic substance that had fallen in its way.

The decay of shells and of corals is also believed to be another source from which large quantities of Chalk arose. In the warm southern seas by the Sandwich Islands, but especially by Australia, vast piles of corals are now found to extend for more than one thousand miles in length, and from three to four hundred in breadth. By the dashing of the waves against these coral walls, large portions are continually broken off and rolled into powder; and as this white powder settles at the bottom of large lagoons or basins found amongst the coral walls, a soft limy white mud rapidly accumulates, which looks when dried, like our ancient Chalk. It is also believed that a great deal of the soft white chalky mud now found at the bottom of the sea, in the neighbourhood of coral reefs, has passed through the bodies of worms; the stony masses of the corals being everywhere bored by these silent workman.* Other portions may have passed through the bodies of a peculiar kind of fishes, which in clear sea water can be distinctly seen quietly browsing in great numbers on the soft living coral walls, like herds of cattle grazing in a field. And on opening the bodies of these fishes, their intestines have been found filled with soft impure Chalk.

Land appears to have dipped down to the edges of the ocean in which the Chalk strata were deposited, as drifted wood and a few plants are occasionally met with. (10) That the waters of the Chalk ocean were deep, we gather from the fact, that no kinds of corals are found in its beds which require much light and warmth, whilst those that live in deep waters are numerous. Also shells that frequent deep waters, such as the ascending and descending chambered shells of the ammonites, nautilites, and belemnites, are numerous, as well as several other chambered shells peculiar to the Chalk formation, termed the Scaphites, Hamites, and Turrilites. Various species of bivalve shells, especially the terebratula, many of which live in deep waters, are very abundant. But the most peculiar, and therefore most characteristic shell of the whole Chalk formation, is a kind of oyster called the *Inoceramus*, which is marked by its fibrous texture.

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* The amount of soil deposited by worms, when quietly left to carry forward their work, is very large. See remarks on this subject in 'Observing Eye,' page 138, third edition.

Spiral univalve shells are met with, but they are comparatively few. It is probable that the deep waters in which the Chalk was deposited, were not suited to the inhabitants of shells possessing heads and eyes, and which therefore required shallow waters in which to see their food. (11) Sponges and other zoophytes, or plant-like animals, as well as animalcules, swarm in the Chalk. We have only to brush a small piece in water, dry the particles thus obtained, and place them under a powerful microscope, and we shall find that the Chalk will prove nearly one entire collection of shells and corals. Numbers of the shells being so minute, that upwards of a million are contained in a cubic inch of the rock. Many of these minute fossils appear to be the cases or shells of animalcules, known by the name of Foramenifera.* Several fossil fish have been collected from the beds of the Chalk, with the separate teeth, palates and scales of the shark families. The bones of large saurian animals are also met with, but they are rare. The fine preservation in which many of the delicate parts of the Chalk fossils are found, is another reason for rendering it probable that the whole formation was deposited in deep and tranquil seas.

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* Foramenifera,—animalcules having perforated shells.

Balls composed of a mixture of clay, sulphur, and iron (called iron pyrites), and having a radiating diverging structure are numerous in Chalk, as well as large spines of echini or sea-urchin shells.

Chalk frequently holds silex and magnesia in its substance. The Magnesian Earth forms the fine pencilled lines and minute black spots, like grains of gunpowder, that sometimes sprinkle the face of Chalk; whilst the siliceous earth usually separates from the Chalk, and settles into a distinct body, forming the hard stone of flint.

The Cretaceous or chalky group shews but little sign of the strata or layer formation, such as is seen in the old limestones. Probably the softness of its beds caused it to yield to a pressure, which has frequently broken into innumerable angular fragments, the flinty masses imbedded in its substance.

In England white Chalk averages a depth of one thousand feet. It is principally developed on the eastern and southern sides of the kingdom. The first beds that rest upon the Green sand are termed the Lower Chalk. They form its hardest portions and are often of a grey hue, being mixed with clayey earth. In parts of Yorkshire and in the Alps, Chalk is frequently of a fine red colour. The highest beds of Chalk in England and France consist of pure white lime, usually too soft for building, but containing nodules or balls of flint arranged in pretty regular layers, varying from the size of a nut to masses several feet in circumference. Besides these balls, there are sheets of flint that run for miles through the Chalk beds, and are called tabular flint. These sheets seldom exceed the thickness of two or three inches.(12) The siliceous earth of which flint is composed, is believed to have risen in the waters of boiling-hot springs, and in its dissolved state to have percolated through the masses of Chalk, encrusting organic substances such as shells, sponges and corals, with its earthy particles, which fossils are frequently tinged of a brown hue by the presence of iron in the silex.

The perfect mould which flint has formed of the substances upon which it settled, is a clear proof that it was once in a liquid state; every sharp delicate point having been preserved, and the cavities in shells and sponges filled up. The large hollows often seen in flint balls, appear to have arisen, from the soft parts of the substance into which the liquid flint first entered, decaying, and so forming a cavity; whilst the siliceous earth went on settling around the outside.

Race after race of animals lived and died during the Chalk deposition, and were successively buried under the gentle flowing of its white earth. A large proportion of the delicate shells and coralines of the Chalk are reduced to a pounded state by long continued movements in water. But in all its unrolled beds, the perfect forms of the fragile shells, with their delicate spines still attached to them, shew that the animals lived and died upon or near the spot where their remains are imbedded. Strata thus loaded with the exuviæ of innumerable generations of organic beings, afford strong proof of a lapse of time in their formation.

After the Chalk depositions came to a close, a long period of quiet appears to have followed, during which the surface of the Chalk, by the washing of waters over it, became in places deeply furrowed and excavated. In other districts, portions of the Chalk rose above the waters, forming islands, upon which trees appear to have grown; and Sir C. Lyell believes the long tunnels sometimes seen in Chalk pits, that are filled with sand and gravel, were made by rain water sinking into the Chalk, after it had passed through the roots of old trees. In its passage through the trees, the water having imbibed the carbonic acid gas of the wood, dissolved the Chalk, and its rills carrying the dissolved earth downwards, formed the tubular cavities we see. These tubes are generally lined and stiffened by fine clay that seems to have separated from the Chalk and settled around them. The whole of the tubes in the course of time becoming filled with sand and pebbles, washed into them by successive floods.

(13) In the Alps and Jura mountains, (14) the tremendous heat and pressure to which Chalk was subjected, at the time the Alpine districts were upheaved, appears to have changed its character, much of the

substance of Chalk in those districts being converted into a hard crystaline rock, like the limestones of the Transition and Primary periods. In the history the Radiated animals, it was noticed that heat under a great pressure soon changes Chalk into marble. To ascertain the certainty of this fact, a lump of Chalk was rammed with force into the barrel of a gun, and the gun barrel being placed in a fierce fire, and left for some time, was afterwards broken, on which a perfect little piece of marble fell to the ground.

With the history of the Chalk formation we close the Secondary series. The Tertiary rocks follow, in which the range of animal life presents quite a new character. Scarcely one single individual species, is found to have passed on from the Secondary into the Tertiary strata. Sponges, corals, shells, crustacean animals, fishes, and reptiles still remain, but we find their forms are varied to suit a new state of the Earth. This fact affords another striking proof, that the one Presiding Ruler exercises a selecting choice, and it also affords a grand evidence of the fullness of his creative powers.

QUESTIONS.

What took place on the crust of the Earth after the Wealden beds were completed? .... (1)
What vast deposits were laid upon the Wealden beds?... (2)
How deep is the Chalk formation? .... (3)
What kind of fossils does Chalk contain? .... (4)

Into how many parts is the Chalk group divided, and name them?	(5)
Into how many beds is the Green sand divided?	(6)
Of what is Green sand formed?	(7)
What divides the Green sand?	(8)
What overspread the Green sand and Gault clay?	(9)
Why is Chalk supposed to have been settled in deep waters?	(10)
Is Chalk rich or poor in fossils?	(11)
What is flint believed to be?	(12)
Where is Chalk converted into hard stone?	(13)
From what cause does this change arise?	(14)

FOURTH DIVISION.

TERTIARY FORMATION.

CHAPTER 20.

EOCENE PERIOD.

THE rocks in the Tertiary formation comprise all the regular marl, clay, lime and sandstone deposits above the chalk. They are distinguished from the Secondary rocks by their shells, and by containing the fossil bones of higher orders of animals. Three thousand ascertained species of animals and plants are met with in these rocks, all of which, with the exception of two or three species, are now extinct. They are also remarkable for frequent alterations from salt to fresh-water deposits.

A period of repose appears to have occurred after the completion of the Chalk formation, during which a material change took place in the level of the land and sea. A large portion of Europe, Asia, Africa and America rose from the depths of the waters, yet so slowly, that (1) the surface of the chalk is frequently grooved with the washing of the gentle waves that played on its face.(2) In other parts the chalk is found deeply furrowed, broken and torn away, apparently by the action of torrents and inundations. In places where the chalk was most deeply excavated, vast hollows or basins were formed, that became the sites of estuaries, and of lakes equal to the size of inland seas. In (3) many of these situations, and in hollows amongst the partially uplifted granites, alternate strata of marine and of fresh-water beds, mixed with volcanic ashes, were deposited; which strata are termed the *Tertiary Series.*

These Tertiary beds are now dry land, and form fertile countries, supporting busy communities of the human race.

(4) By noticing in these beds the greater or less number of shells which resemble our living species, Sir Charles Lyell has been able to divide the Tertiary strata, formed in these hollows, into three groups.

The highest beds he calls Pliocene,* which contain ninety shells in a hundred like our living species.

The middle group, the Miocene,† which contains about eighty shells in a hundred like the living species.

The lowest beds, the Eocene or dawn of present things, in which no more than two or three shells in a hundred resemble our living shells; the rest are extinct races.‡

On digging into the Tertiary strata, we perceive with admiring eye,(5) the state of animal and vegetable life which pervaded the surface of the earth during its formation. In the Secondary rocks, huge reptiles had occupied the principal place in the animal kingdom. (6) In the Tertiary they decline, and mammalian animals, that nourish their young by milk were introduced;

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* The recent, or new. † The less recent.

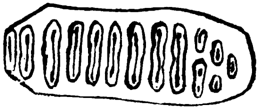
‡ Our present shells are calculated at ten thousand species.

yet all appear to be of extinct races, although they approached in form to the species of our own times. They chiefly consisted of such quadrupeds as live beside rivers and lakes, and are related to the tapirs and thick skinned hippopotamus.

Shells are numerous in the Tertiary beds, and from being less pressed upon, than in rocks of a lower formation, are often in good preservation. (7) These delicate coverings of the molluscous families, are of great value to the geologist, since they determine many events relating to the rocks in which they are found. By their forms, naturalists can judge whether they lived in quiet or turbulent times, in deep or shallow districts, in salt, fresh, or brackish waters; and as the habits of molluscous animals are stamped upon their shells, we can learn whether they lived upon vegetables or flesh, and whether they lived alone or congregated in groups. Fossil shells therefore become the clear interpreters of many difficult questions, that constantly arise during the study of the rocky coverings of the globe.

By comparative anatomy, Baron Cuvier has caused fossil bones to perform much the same office. A shell usually forms a perfect whole, but it is not so with the skeleton of an animal; its bones united in life by muscles, separate after death, and until within a few years it was not thought possible (8) that bones could afford a clue, by which to judge of the habits, or shape of the animals to which they belonged. To Baron Cuvier we are indebted for this discovery. Having been led to notice the difference between the bones of a bear and those of an elephant, he was induced to regard every animal as a machine; the parts of which are made mutually dependent upon each other, and exquisitely adapted to aid one another, in accomplishing the part they are destined to perform.

By the shape of a bird's leg or claw we can judge of its habits. In the parrot tribes the claws are adapted to climb trees, and to perch on branches. In the eagle they are constructed to tear and to lacerate their prey. Water birds have their feet formed like paddles or oars, and birds that frequent marshes have long wide feet by which to support themselves on shaking, sinking ground. The Baron noticed that the teeth of flesh eating animals, like the Bengal tiger, are not suited for grinding vegetables, but are adapted for tearing and cracking hard substances, such as bones, The jaws of carnivorous animals have no grinding motion, but open and shut like shears, and the muscles act as levers to the jaws, being firmly set into deep grooves in the bones of the head. The shoulders and leg bones of such animals, are set for swift powers of motion. The feet are prepared with claws for seizing and tearing their prey, and the stomach is adapted for digesting flesh. In order that such animals may have ability to lay hold of their victims, the paw is made with joints of easy motion; and to give the animal power to throw its prey over its back, and yet to lift up the head whilst carrying it off, the muscles that run from the head to the back are fastened into deep grooves, made in the vertebra of the back bone. In animals that live upon vegetables, the sharp fang of the carnivorous animal's tooth is wanting, and the top of the vegetable grinder is made flat. The enamel, instead of covering the whole surface of the tooth, runs up in plates between the bony matter, which bony matter being less hard wears away, and so leaves the enamel to form a rough surface, such as we see in the tooth of the horse and elephant. The jaws of such herbivorous animals are loosely hung together, to allow of a grinding movement, and the rest of the animal frame is made in character with this grinding mouth. If therefore a person instructed in comparative anatomy (that is, in the harmony of bones), meets with only one single tooth, he can, after a little consideration, explain several circumstances connected with the natural history of the creature to which it once belonged, and with its natural history he can also gain some idea of the land in which it lived.



Surface of the Elephant's Tooth.

If the tooth shew that the animal fed upon vegetables, it would follow that the rocky soil in which the tooth was buried, once belonged to a range of grounds on which forests and grasses flourished, and to produce a soil suitable for such vegetation, the country where the animal had roamed at large, must have been diversified with hills and vallies, and with streams and rivers to carry off its superfluous waters. But until the light of comparative anatomy dawned upon the piles of bones, that have been dug out of the Tertiary beds around Paris, they were regarded only as curious relics of odd forms, that awakened curiosity but imparted no facts. It is therefore to Baron Cuvier that we are entirely indebted for the knowledge of many extraordinary animals, and for the information which their history has thrown upon the state of things during the Tertiary epoch.

We have already remarked that the Tertiary series is a deposit limited to particular situations, such as basins, gulfs, and estuaries, formed by depressions in the chalk or in the older granites. In Hampshire, one of these basins extended into the Isle of Wight. Several others occupied extensive tracts in portions of England, Scotland, France, and other countries, (9) but the two most important with which we are acquainted, are termed the London and Paris basins. These basins appear to have been depressions, which by a kind of estuary, opened on one side into the sea, and on the other side were fed by rivers, charged with the spoils of the country through which they had passed. The basin or lake upon which the city of Paris now stands, was one hundred miles wide, and one hundred and eighty long; and the basin or lake upon which London now stands, was bounded by the chalk hills of Wiltshire, Oxfordshire, and Hertfordshire—it just touched upon Norfolk, and extended southward to the downs in Sussex, stretching on the east to the mouth of the Thames.

The deposits first thrown down in the chalk basins, are termed the Eocene or dawn. (10)They were simply sand, mottled clays, and well-rolled flint pebbles derived from the chalk, varying in size from a pea to that of an egg. Some of these lowest beds contain banks of oysters and other marine shells, mingled with fresh-water shells. Some of the clay is very stiff, and is called Plastic clay, being used for pottery.

(11) In the London basin, these deposits are covered by a blue clay from one to six hundred feet in depth, called the London-clay; (12) in which have been found the bones of elephants and other animals, the remains of fishes, crustacea and shells; with such accumulations of tropical fruits, plants and seeds of the date, cocoa, cotton, bean, cucumber, and pepper plants, that the existence of a group of spice islands at no great distance, seems necessary to account for such tropical productions. The remains of crocodiles, serpents, turtles, and of birds drifted by ancient currents from other climes also abound. It was the sight of the London-clay fossils in the Isle of Sheppy, when Mr. Mantell (the Sussex geologist) was a youth, that excited his interest in their study, and led to his future interesting and valuable discoveries.

Upon the London clay is a deposit of gravel, sometimes amounting to six hundred feet in depth.

The Paris basin possesses no clay that resembles the London deposit. But after the first settlements from the chalk, (13) there followed a series of white and green marls, with limestones of varying qualities.

One of the most interesting beds of limestone found in the Paris basin, is called the Gypseous series. This series is largely quarried at Montmartre, in the neighbourhood of Paris, as well as on the banks of the Seine, for the sake of the plaster which it yields. Its beds contain plants, land and river shells, the bones of fresh-water fish, crocodiles, and other reptiles. The skeletons of some of the quadrupeds are entire, and their delicate extremities are so well preserved, that (14) it is supposed the bodies of these animals, clothed in their flesh and skin, must have fallen into a river, and being floated by the stream into the centre of the Paris basin, where they became rapidly surrounded by the sulphate of lime its waters held in solution, and were constantly precipitating. Such a process is now taking place on the east of Java, where sulphurous lime water, as white as milk, flows down the volcanic mountain of Idunna into the sea, enclosing in its sediment whatever falls in its way.

(15) In the Eocene formation have been found about ten species of birds, fifty species of quadrupeds, forty of which appear to have been thick skinned like the rhinoceros,* and the rest resemble foxes, dormice, squirrels, &c.; but all are of extinct species. It was long after such relics had been collected from the Paris basin, that Baron Cuvier, struck by the piles of singular bones continually laid aside, began to suspect he was every day treading on a soil filled with the remains of unknown animals.

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* Called the Pachydermata, or thick skinned order.

He offered rewards to the workmen in the quarries for fresh specimens, and soon obtained a greater number of bones than any of the collectors who had preceded him. "From the first moment I perceived," he informs us, "that there were many different species in our quarries; that they belonged to various genera, and that the species of the different genera were often of the same size, so that the size alone, rather confused than assisted my arrangement. I was in the situation of a man who had been given, *pell mell*, the mutilated and incomplete fragments of a hundred skeletons, belonging to twenty sorts of animals, and it was required that each bone should be joined to that to which it belonged. It was a resurrection in miniature; but the unchangeable laws prescribed to living beings were my directors. At the voice of comparative anatomy, each bone, each fragment regained its place. I have no words to describe the pleasure I experienced, on perceiving that as I discovered one character, all the consequences more or less foreseen of this character, were successively developed. The feet were conformable to what the teeth had announced, the teeth to the feet; the bones to the legs, and everything that ought to reunite these skeleton parts, were conformable to them. In short each of the species sprung up as it were from out of its own elements."

Amongst these animals thus restored by the Baron, was one about the size of a horse, but possessing a head more massive, and the extremities were thicker and shorter.*

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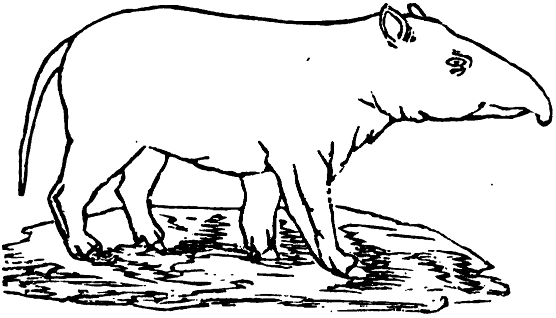
* Palæotherium.

On each foot were three large toes, rounded and unprovided with claws; and the upper jaw was much longer than the under.



Of such animals Cuvier has attempted to give us a few representations. Clothing his skeletons with flesh and skin such as he believed they possessed.

(16) After the gypsum of the Paris basin had been deposited, the sea, from some change in the level of the land, rolled in its waters, and left upon the gypsum beds a range of sea sands and pebbles, in which are found marine shells. Again the land rose, and a fresh water deposit of limy marls and siliceous mixtures took place, containing shells and petrified wood, amongst which is found a limestone, noted for its valuable qualities as a millstone.

In the early Tertiary periods, vast forests of pine trees, several cypresses, yews, junipers, with oaks, poplars and beeches, (17) grew on the bed of the present altic sea. (18) A species of extinct pine which grew these forests, yielded a resin that formed the beautiful substance called amber. This fine hardened resin is now obtained from beds of lignite on the coasts of Prussia, and is often washed up by the action of the sea and drifted on shore. Eight hundred species of insects have been found inclosed in this transparent, and once sticky amber; most of which belong to species, and even to genera, unlike any that are now seen; the few that are known, resemble the insects of more southern climes.

In the centre of France, can be clearly traced several groups of fresh water rocks, formed at this period in spacious lakes between low mountains, and which lakes had been fed by the drainage of marshes and rivers. During a long scene of repose, beds of marl and sand, several hundred feet in thickness became deposited in these hollows, together with siliceous and calcareous rocks, whose materials had been precipitated from the waters of mineral springs. In these strata are enclosed shells, insects, the remains of crocodiles, tortoises. the bones of water fowl with their eggs, together with skeletons of quadrupeds; none of which resemble those inclosed in the gypsum of the Paris basin.

(19) Amongst these fresh water limestones, a remarkable rock occurs in Auvergne, chiefly composed of the shelly cases of caddis worms. The Eocene lakes of Auvergne swarmed with these worms, and with multitudes of minute shells. Upon the slimy skin of the worms, hundreds of such shells adhered; and as the worms moved about clothed in their shelly tubes, the

lime that was constantly falling from the waters, cemented them into a limestone, that attained to the depth of many feet; ten or twelve cases being packed into every cubic inch of the rock.

To this tranquil deposition of rocks, succeeded an era of violent volcanic eruptions. Sheets of lava were poured over the plains—the lakes became drained of their waters,—and the present mountains of the world were continually elevated. This state of things carries us to the Miocene period.

QUESTIONS.

What appearance on the Chalk marks a long season of quiet after its settlement? (1)
What did inundations and torrents in some places produce in the chalk? (2)
What was formed in these hollows? (3)
By what rule are these Tertiary beds divided into three sets? (4)
What is admiringly noticed on opening the Tertiary beds? (5)
What kind of quadrupeds are met with in the Tertiary beds? (6)
Of what use are shells to the Geologist? (7)
What has Baron Cuvier enabled us to gather from the examination of bones, or by comparative anatomy? (8)
Which are the two most extensive Tertiary hollows or basins known? (9)
What deposits were first thrown down in these basins? (10)
What followed Chalk Rubble in the London basin? (11)
What kind of fossils are found in the London clay? (12)
What covered the Chalk Rubble in the Paris basin? (13)
In what part of the Paris basin have remarkable animal bones been found? (14)
Is the Eocene Period rich in animals? (15)
What strata followed the Paris gypsum? (16)
Where was our amber formed? (17), (18)
Of what was the fresh water rock formed in Auvergne? (19)

FOURTH DIVISION.

TERTIARY ROCKS.

CHAPTER 21.

THE MIOCENE FORMATIONS, OR VOLCANIC ERA.

The Eocene period was succeeded by the Miocene or more recent period, during which great changes appear to have taken place in the newly-raised continents, described in our last chapter.

(1) Internal commotions caused many parts of the land alternately to rise and to sink, by which means salt water and fresh, successively covered large spaces of ground. (2) Shells increased enormously in number, and when the waters retreated, large districts were left covered with their remains. A considerable extent of country between the Pyrenees and the Gironde, in France, termed the Faluns (from its sands being mixed with shells), is deeply covered with a mixture of shells and coral, some pounded, some entire; seven hundred varieties of marine and land species have been collected from these Faluns. Another deposit of shells in Switzerland is cemented together into a soft green stone, and is called the *Molasse*, from *mol*, soft, because its stone is easily cut in the quarries. Similar kinds of deposits are met with in other parts of Europe, in America, and also in Asia at the feet of the Himmalaya mountains.

(3) Powerful volcanoes burst forth at this period, and as their gases and red hot lavas drove through the old granite and slate rocks, they forced them upwards, tilting also in their passage the chalk and overlying Eocene Tertiary beds. Sheets of volcanic lava and mud became mixed with breccias, composed of the rocks of all ages; and formed in many districts a thickness of many hundred feet of soil upon the Eocene deposits. The effects of these commotions are still visible on the face of the Earth. In France, the district of Auvergne presents for twenty miles in extent, one continuous scene of former confusions; the boundaries of former lakes are still visible, as well as the openings of numerous volcanoes, by whose explosions passages were torn open in the midst of the mountains through which the waters of the lakes were discharged; until new walls and banks of lava collecting, the waters became resettled, again to be overturned by fresh eruptions. (4) At the period of these outbursts, large forests of rich pastures bordered the Tertiary lakes, and were the haunts of extinct races of huge elephants, tribes of the rhinoceros, tapirs, hippopotamus, hyenas, and of cats the size of lions, as well as of other wild beasts; (5) the bones of which animals are found buried under the volcanic cinders and mud that overspread the land, during the repeated explosions that took place in this era.

One of the highest summits in the volcanic district of Auvergne, is called Puy le Dôme. This mountain rises two thousand feet above the level of the plain on which it stands, and the streams of lava that once issued from the sides of the mountain, can still be traced in their descent into the vale below.

On the banks of the Rhine, many volcanoes also burst forth, whilst others of older date seem to have remained quiet.

The vast flow of trap thus thrown over the surface of the land, yielded as it decomposed, (6) a rich and fertile soil, that gradually prepared the way for the growth of herbage, suitable to support our present numerous race of animals.*

QUESTIONS.

What took place in the land during the Miocene period ? (1)
What was observed when the waters retreated? .... (2)
What powerful action took place in this period? .... (3)
What bordered the Tertiary lakes? .... (4)
Under what were the animals of this period buried ? .... (5)
What did the vast amount of Trap thrown out at this period produce? .... (6)

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* Sand, clay, lime, and potash are blended in the Trap rocks, in admirable proportions, for the growth of vegetation.—LYELL

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FOURTH DIVISION.

TERTIARY ROCKS.

CHAPTER 22.

THE PLIOCENE GROUP.

This formation consists of sands, marls, clays, and conglomerates, intermixed with deep beds of shells and animalcule cases, sheets of lava, coarse shelly limestones, and soft sandstones.

(1) During the formation of this group, the surface of the Earth arrived at nearly its present geographical arrangements. The old continents which had supplied their sediments for the composition of our rocks, appear to have sunk beneath the waters of the Atlantic and Pacific oceans, and the greater part of Europe, Asia, Africa, and America, to have now arisen into sight. In consequence of this

elevation, marine deposits become more scarce on the land, but the remains of land animals abundantly increased. Not that the state of the Earth was settled, for during the whole of the Pliocene era, our present continents evidently underwent repeated elevations and depressions, supporting at one time forests and land quadrupeds, then submerged and thickly overlaid with sea shells, and again lifted up.

(2) In this era whole regions of volcanoes burst forth, whose lofty but now tranquil cones can be seen in Catalonia, in Spain, in France, Switzerland, Asia, and in America. (3) The Alps, the Carpathian mountains, and other lofty ranges, were at this period partially upheaved. The researches of (4) Sir Robert Murchison have established this fact, by his finding deep beds of limestone, characteristic of the Tertiary period, on the summit of one of the loftiest of the Alps, full ten thousand feet above the level of the sea.

This limestone is chiefly composed of a shell found in the Paris basin, called the Nummulite. The nummulite is a small round chambered shell, that varies in its size from that of a pin's point to one inch and a half across.

It swarmed in many parts of the world during the Eocene period, for it is found in rocks that are many thousand feet thick, both in the Carpathian, Alps, and Pyrenean mountains. The nummulitic rock can also be

A Nummulite from the pyramids of Egypt, part of the external shell removed, shewing the air chambers.

traced into Africa, over Asia Minor, and through Persia to the Indies.

(5) The basaltic columns of the north of Ireland and Scotland were also formed at this period, and as the red hot trap of which they are composed rose through the under lying chalk, their heated masses converted the soft chalk into a hard crystalised marble. The same effect is observed to have taken place in the Alpine ranges, the chalk fossils in this marble bespeaking the nature of its origin.

On each side of the Appenines in Italy, are low ranges of mountains formed of brown and blue marls, of yellow sands, and conglomerates, which arose at this period, formed by the waste of the Secondary rocks of which the larger Appenines are composed, those mountains having been upheaved at an earlier period.

We learn also that the grand volcanic mountain of Etna, with the island of Sicily, was raised from the bed of the Mediterranean sea in the Pliocene era. The rocks of the island, and the whole face of the ground being mixed with vast beds of recent shells, tog ther with volcanic ashes and mud.

(6) In the Eocene period, incredible amounts of microscopic infusoria, or as some think of siliceous* plants, too minute for the eye to see, settled at the bottom of lakes and formed a hard stone called

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* Those fine siliceous plants or substances abound in fresh-water lakes and ponds in England, and are termed by those who think they are plants—Diatomaceæ.

tripoli. These beds were lifted up in the Pliocene era. At Berlin in Bohemia one stratum of tripoli stone runs for a great distance, and is fourteen feet thick. This stone when examined with a powerful microscope is found to consist of siliceous plates, either of animal or vegetable growth, united together without any visible cement; the plates being so small that forty-one millions of individuals are estimated to lie on every cubic inch of the rock. Tripoli is used from its hardness as a polishing powder; every stroke the workman takes may therefore crush to atoms millions of perfect fossils.

(7) During the changes and inundations which the Earth underwent in the Tertiary era, new ranges of soils were continually forming, which are distinguished by the kind of fossils they contain. But whilst new deposits can be traced in some quarters, enormous portions of the under strata are also found to have been torn away by the retiring floods, and the softer beds being removed, valleys were widened and deepened, and river channels cut out.

(8) The vast movements which took place at this time in the sea, as well as on land, brought down from the north immense masses of floating ice, (9) which charged with fragments of the different rocky regions from which they came, stranded on the partially risen continents, and strewed the surface of our land with their stony rubble.

(10) From this period, the fossils in every fresh deposit mark that an alteration had taken place in the

temperature of Europe. Instead of palms, spices, and the plants of warm climates, we find imbedded in the soil, fragments of trees such as grow in our present cool and temperate regions. And in accordance with these changes in the atmosphere, and in the herbage of the land, so we find the character of the animals approached nearer to our own existing tribes than in any lower formation.

(11) In the strata of this period are the first traces of ruminant animals, such as the ox and the deer. It was also the age of elephants, which were often of gigantic sizes. Birds, reptiles, and fishes also abounded, but of species different to our own.

Prodigious masses of shells accumulating at this period in all parts of the world, have since been raised from under the waters, and becoming mixed with sand, lime and clay, have formed ranges of low hills. Near Palermo in Italy, (12) such a range of hills is composed almost entirely of the same species of shells as those which now inhabit the Mediterranean sea; a sure evidence of the late formation of these grounds.

(13) On the eastern side of England deep masses of marine shells, sponges and corals are also found amidst loam, sand and clay.

This deposit is provincially called crag,* and is in some places more than fifty feet in depth. From the amount of lime which the shells contain, crag has long been used by the farmers of Suffolk and Essex for manuring their lands. These beds of crag extend along the coast for forty or fifty miles, and are divided into Coralline or lowermost crag, and Red crag. The foundation rock of that part of England is white chalk, on the chalk rests the London or Eocene clay, and upon the clay, the Coralline crag. In the Suffolk crag, the teeth of several fishes of the shark family have been found, together with the ear bones of whales.

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* Crag—from Gravel.

The Norwich crag seems to be a later deposit than the Suffolk crag, and is principally met with on the banks of the river Yare, about five miles from Norwich; it contains a mixture of marine and fresh-water shells, with the bones of fishes and of some animals.

(14) Upon the shelly beds of Norfolk and Suffolk, lies a stratum of silt and sand, which was evidently brought down by fresh-water rivers from some neighbouring lands, and deposited upon the shells scattered over the bed of the sea.

Dense forests appear to have been bordered these rivers, and to have extended from Lincolnshire to Norfolk. (15) In the lower part of the cliffs near Cromer, layers of these forest trees can be clearly seen in a friable state, resting in the silt. The forests appear to have been inhabited by various animals, since in the layers of mud around the trees, are found the bones of the horse, pig, deer, rat, and of the beaver, water mole and monkey; with the jaws and teeth of field mice, and huge bones and teeth of the mammoth elephant. At a short distance off the Norfolk coast, are extensive mud banks; and from these banks it is calculated that the fishermen in dredging for oysters, have from first to last, brought to land the teeth of not less than two thousand mammoth elephants. The land upon which these animals lived, with the beds its drifted soil had settled in the sea, at length sunk down, and a vast rush of waters and of ice coming from the north, brought with them new deposits of broken rocks, rubble, and mud, the nature of which formations come under the appellation of Drift and Alluvium. They form the last deposits on the surface of the globe, and we shall consider them in our next chapter.

In beholding the immense amount of fossils entombed in the deep piles of rocks through which we have been ascending, from the hot granites to the soil upon which we stand, it is impossible not to be struck with the regular order in which they have been deposited. One great deluge of water would have blended all animals together, but in the rocks of the earth, genera, species, and families rest distinct and alone, marking long and numerous successions of ages, in which various deluges and other causes destroyed whole races, to be succeeded by fresh displays of creative power. Throughout each series, our Creator has ever manifested himself as a Being rejoicing in life. We read in the Bible that light, energy, and happiness are essential parts of his divine attributes. And such qualities we find He delights to impart to his living creatures. It is true that the largest proportion of ancient animals entombed in the rocks were tenants of the boisterous seas, but judging by the reports of mariners, who now plough the ocean's wave, much ppiness is the portion of that ocean's family.

Bishop Anderson, in sailing to Rupert's Land, remarks, "I might also dwell on the tokens of God's goodness in the enjoyment which seems to fill the tenants of the sea. They seem to sport and play about in the exstacy of being. Whether it be the whale sending up the column of water into the air—the seals and porpoises crowding round the vessel—the little stormy petrel following close behind and picking up fragments—or the white polar bear, scarcely to be distinguished from the masses of ice by its side; all these we saw in their turn, and they reminded us how 'God openeth His hand and satisfieth the desires of every living thing.' We felt that the sea was a world in itself; in every part of it bearing witness to God, and that though we cannot hear the voice, there is a tribute of praise ever ascending from it. That the ice, and frost and snow, as well as the expanse of the calm and quiet sea, praise the Lord and reflect His glory !"—*Ps.* cxlviii:, 8.

QUESTIONS.

At what did the Earth arrive during the Pliocene era? ... (1)
What active agents were at work ?.............................. (2)
What mountains were elevated at this period?............... (3)
How is it known these mountains then rose ? .... (4)
What basaltic columns were formed at this period?......... (5)
By what was the rock of Tripoli formed? . ... (6)
What was continually forming in the Pliocene era?......... (7)

What was brought from the North by the movements of the land and water? .... (8)

What did the ice bring down with it? .... (9)

What alteration did these changes on the Earth produce on the air? .... (10)

What kind ot animals are first found in the Pliocene era? (11)

What species of shells did many of the Pliocene era resemble? .... (12)

What is the Crag formation? .... (13)

What settled upon the Crag? .... (14)

What is found in the mud and silt over the Crag? .... (15)

FIFTH DIVISION.

CHAPTER 23.

DILUVIUM OR DRIFT PERIOD, AND THE ALLUVIUM OR LAST PERIOD.

THESE settlements are the uppermost accumulations on the face of the Earth, consisting of mud, sand, gravel, peat-bogs, and boulders of rocks of every age. In these deposits are found fragments of the works of man, shells, and the remains of existing species of animals, with the skeletons of some extinct quadrupeds.

(1) The term Alluvium is taken from *Alluvio,* an inundation, and is applied to the last settlements on the surface of the Earth, because the pebbles and sand lying between the vegetable mould and the nearest rocks, frequently resemble the washed bed of a river.

Immediately after the formation of the Pliocene deposits, described in our last chapter, (2) the land appears to have undergone great changes, arising from repeated submergencies and elevations. These fluctuations in its level produced inundations that flooded the ancient caverns, deposited much mud on their subterranean floors, and (3) destroyed whole races of the wild beasts of the former era. In England, Germany, and other parts of the world, many deep caverns are found, which appear to have been the haunts of ancient carnivorous animals, their floors being covered with vast collections and varieties of bones now sunken in beds of mud. In all parts of the world numerous bones are also met with, simply lying in mud and gravel. Around Geneva there are beds of well arranged rubble, ten feet below the cultivated soil, which contain the bones of the mole, fox, sheep, ox, pig, rat, mouse, green frog and lizard, but all of species no longer found in Europe.

During the Alluvium and Drift periods, the waters that repeatedly covered Europe, were loaded with mud and pebbles, and being driven onwards by varying currents, subject to whirling eddies, have left their deposits resting in many sloping contorted lines.

This changeful character in the top strata of sand and gravel,* may often be seen at the sides of high banks, and of cliffs by the sea side. (4) Most of the small and huge boulders of stone that settled upon the

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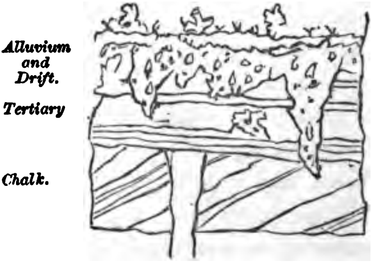
* Gravel is composed of the shivered fragments of beds of flint and of many older rocks rolled by water into various sized pebbles. Gravel fills up many uneven portions of the surface of the Earth.



Chalk intersected by a trap dyke, and gravel filling up vacancies in the top strata.

sunken beds of the Pliocene crag and silt, belonged to rocks situated hundreds of miles off. The waters that spread these masses abroad, usually appear to have come from the polar regions, and to have passed over Europe in one continuous stream.

In England, the rocky fragments of this northern drift, that came sweeping down from Scotland, can be seen in Lancashire, Cheshire, Shropshire, Worcestershire, and in Norfolk. And in no place is it better displayed than at the sides of the cliffs that run between Cromer and Happisburgh. Huge fragments of chalk frequently occur in this deposit, which are often placed amidst contorted layers of mud and sand, that probably whirled in many an eddy around the chalky boulder, or were driven up in heavy masses by the force of icebergs as they pushed the boulders forward.

In Scotland, this northern drift of mud, sand, and rocky fragments, is sometimes stratified; at other times, for a depth of more than one hundred feet, it is wholly devoid of stratifications, when the mass is given the name of Till.

Other streams besides the great northen drift, seem to have passed over different quarters of the globe, leaving in some instances enormous boulders, many tons in weight, which had been transported from far distant lands. To account for the removal of such masses of stone, has been a serious question amongst geologists, for it is well known that stone is not a floating substance. At length light dawned on this subject, in consequence of close observation, (an excellent handmaid to inquiry) having led to the discovery, (6) that vast blocks of rock are now at this day, frequently transported to distant lands on floating ice; and that during this transport, their sides, and the rocks upon which they rest, are polished, marked, and scratched, by the grinding, pushing force of their movement; just as the top of a table would be deeply lined by drawing broken edges of glass over its surface. These appearances being found on many of the boulders, scattered over the surface of the Earth, has induced the belief, that drifted lumps of rock, as well as many smaller particles, have been transported to their present situations on floating ice. In our northern seas, icebergs are constantly met with, one, two, and some even five miles in length, and as they are driven slowly on through the waters, they are found to bear on their cold bosoms large portions of the earth and rock torn from the lands on which they were frozen. And on touching against any land or rock, an iceberg is found to grind against the bottom soil with such a tremendous pressure, that hard substances embedded in it, become not only polished and scratched, but sometimes ground down to mud.

When such 'icicles of monstrous form,' reach a warmer clime, they melt away, and strew the land upon which they have been grounded, with the various materials they have imported.

By this glacier transport, many difficulties are removed, connected with the dispersion of scattered rocks over the world.

Sir Charles Lyell remarked at the time he was travelling in Canada, and the United States of America, that extensive ranges of mountain land, elevated some thousand feet above the present level of the sea, were often covered with scattered blocks, grooved and polished on their surfaces. To explain the cause of the high position of such loose masses, as well as to account for the fluted polished appearance of many parts of the rocky mountains themselves, he could only assume, that after the land of North America had acquired its present outline of hill and valley, cliff and ravine, a gradual sinking of the whole continent had taken place, and that whilst the land was gradually lowering, floating masses of northern ice covered the sea, which as they grounded on the land drove before them the rubble of sand and pebbles that strewed the bottom of the waters. All of which substances, on the uplifting or re-emergence of the lands from the ocean, rose with them to their present elevated situations. The slow upheaval of these vast tracts of land, enabled the powerful ice machinery of the glaciers to grind against the rocks in the shallow parts of the ocean, by which action the sharp points of the under rocks were broken off, and the flat surfaces polished and scored; thus producing the effects, which are now distinctly visible on the sides and tops of the present Canadian and other American mountains.

The constant occurrence in all hilly countries of flat terrace-like steps, rising one above another on the sides of elevated ground, especially by the side of rivers, is a clear proof of the long continued sinkings and upheavings of the crust of the Earth during the last periods of its formation. (6) Floods of water appear to have rested for a time in one place, and thus on the land being uplifted, the flat shore or terrace the edges of the waters had cut, also became elevated, and a lower terrace commenced, which in its turn was upheaved. In the Morea, three or four ranges of limestone terraces rise one above the other, the highest exceeding one thousand feet in elevation.

The long continuance of the Drift and Alluvial periods is also marked by the amount of fossil remains settled in their layers, most of which chiefly belong to quadrupeds now extinct, and many of which were of huge dimensions.

(7) Cuvier observes, that skeletons of six or eight species of elephants, some of immense size, but all approaching in form to our living species, are found in most parts of Europe, Asia, and America, lying under the superficial coverings of the Earth.

The mammoth* of Russia measured from fifteen to eighteen feet in height, and also differed from our present elephants in the rounded form of its lower jaw, as well as in having the ribbons of enamel in its teeth narrower and straighter.

Along the eastern shores of England, running from Yorkshire to the mouth of the Thames, and in the south-eastern district as in the neighbourhood of

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* Mammoth is a Russian term applied to a huge elephant.

Brighton, the bones, teeth, and tusks of huge elephants are repeatedly dug out of the ground, as well as dredged up at sea by fishermen. It is however in the vast regions of the icy zone bordering upon Siberia, and in the north of Asia, that their relics are met with in the greatest profusion, and in the most beautiful state of preservation. Along the icy shores from Archangel to Behring's Straits, they are crowded together in such heaps, that at the mouth of the Lena they form, with a mixture of mud, complete islands.

The ivory of the northern tusks is in high request as an article of commerce, possessing the qualities of recent ivory, at the same time that it is less liable to turn yellow; but from being fast blocked up in beds of ice, the tusks can only be obtained during the short thaws of the northern summers.* During a hunting expedition after ivory, a Russian fisherman (8) in 1799 discovered the body of a whole mammoth, which had been enveloped in ice for untold years. This man, after fishing during the season in the river Lena, embarked according to his usual custom along the coast in search of elephant tusks. Passing one day a ridge of ice, he saw some height above the water, a very unusual looking shapeless mass imbedded in the frozen ridge. Four years however passed away without his being able to discover what the substance was. On returning the fifth year to the same spot, he beheld, to his great astonishment, an enormous elephant prostrated on a bank of sand. The ice having thawed, it had slipped from its frozen bed and fallen down. It proved to be an elephant of an extinct species, clothed in its flesh, skin and hair, and looking as perfect as when alive.

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* In 1844 a company of merchants obtained one thousand six hundred pounds weight of mammoth jaws and tusks, and sold them at a higher price than the tusks of the present living elephants.

The fisherman cut off its tusks, which he sold to a merchant for goods that were worth fifty rubles, but he left the body of the prostrate monster on the bank. And it was not until two years afterwards that a Mr. Adams, travelling in that quarter of the world, saw the carcase of the mammoth, and informed the Russian government of this remarkable relic of a former state of the Earth. He found the mammoth much devoured by wild beasts, and the ground all round trampled by the feet of bears, wolves, and foxes. The skeleton was shortly afterwards removed to the Museum in St. Petersburgh. The skin of this mammoth was of a dark grey colour, covered with curling hair of a fawn hue, having wool underneath of a reddish brown, and black bristles thicker than horse-hair, standing out fifteen inches in length. A mane was found on its neck. The hair on that side which had been attacked by the wild beasts was trodden about, much of it was however collected and added to the hair on the under side, when the whole was found to weigh thirty pounds. The head alone with the tusks weighed four hundred nd fourteen pounds; and the skin was of such exraordinary weight, that ten persons found great diffiulty in transporting it from the iceberg island to the nain shore.

In another quarter, a rhinoceros with part of its skin was found imbedded in ice. Bones in innumerable quantities, belonging to various extinct herbivorous animals, are constantly met with in every quarter of the Earth. At the base of the Himmalayan mountains in Asia, bones of bears, huge elks, oxen, horses, camels, birds, and reptiles, are amassed together in strange confusion.

In various parts of North America the bones of whole races of animals, almost unknown at the present day, are found in marshy lands that abound in salt and brackish waters. They lie in such quantities and are of such huge dimensions, that in Kentucky the natives have given one place the appellation of "Big Bone Lick," from believing the profusion of animals which died there, were attracted by the salt in the morasses.

In South America, vast plains termed the "Pampas,"* present for nine hundred miles together the appearance of one sea of waving grass. These plains are believed to have been a gulf or arm of the sea, similar to the Lewis levels: They are principally composed of loam and sand, and contain fresh-water and land shells, with the bones of huge quadrupeds, of the sloth, armadillo, horse, and mastodon† tribes. About sixty years ago the skeleton of a gigantic animal was taken out of a considerable depth of clay, by the side of a river near Buenos Ayres. The skeleton was sent to Madrid, and was placed in the museum of that city, where ⁽⁹⁾ Cuvier, the French naturalist examined it, and styled it the Megatherium, or enormous wild beast. The general form of this animal is most extraordinary, resembling in many of its proportions the family of the sloths, but is of dimensions far exceeding the conceit of the wildest imagination.

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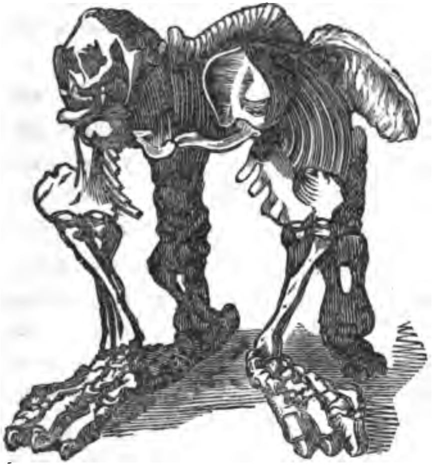
* A name denoting treeless plains.

† Mastodon—a long-bodied kind of elephant, with peculiar formed teeth pointed at the top.

Our living sloths are of slender form, and not much larger than a cat. They have long toes and nails which fold up, so as to enable the animal to walk in the same way, as if our fingers were folded under the palms of the hands. Their arms are double the length of the hind legs, and from their construction, the animal rather crawls than walks, being obliged to drag itself along the ground on its elbows. The proper situation for sloths is on the branches of trees, where they pass from bough to bough, with a rapidity which soon enables them to conceal themselves in the depths of the forest. They live on the leaves and shoots of plants, and until disturbed, never quit a tree till they have stripped it of every leaf.

The megatherium sloth now in the museum at Madrid, is nine feet long and seven feet high. Others have been met with nineteen feet long and nine feet high. The megatherium though larger than a rhinoceros, resembles the sloth in the length of its fore arms, but its hind legs are different, being strong and solid, and three times as large as those of an elephant. From the enormous weight of its body, it is clear the province of this huge animal was not to climb trees, like our sloths, but to dig up their roots and tear down



Megatherium nineteen feet long, nine feet high.

their branches. Its fore foot or hand, is about one yard in length, terminating by large and powerful claws; with such a breadth of foot, the megatherium when moving, must have crept along very slowly, but when resting the whole weight of its body on its tail and two hind feet, and upon one of its fore feet; the other front foot must have formed a strong and powerful instrument for scratching away the earth, from the deep roots of the succulent plants, upon which it principally fed; or for grasping round the body of a tree it was disposed to tear down.

The body of this huge sloth-like creature, was defended from the attack of flies and other depredators, by a strong bony armour, from a quarter to half an inch in thickness. The megatherium appears to have been an intermediate creature, between the sloth, armadillo, and ant-eater.

Its tail was probably clad in armour, and much larger than the tail of any other beast amongst extinct or living quadrupeds. Thus heavily constructed, and ponderously accoutered, it could neither run, leap, climb, nor burrow under the ground; in all its movements it must have been slow; but what need of rapid motion to an animal whose occupation of digging up roots for food made it almost stationary? And what of speed or flight from foes, to a creature whose giant carcase was encased in an impenetrable cuirass, and who by a single pat of its paw, or lash of its tail, could in an instant have demolished the cougar or the crocodile? Secure within the panoply of its bony armour, where was the enemy that would dare to encounter this leviathan of the Pampas? These creatures have ceased to be counted among the living inhabitants of our planet, yet they have left behind them in their fossil bones, imperishable monuments of the consummate skill with which they were constructed. Each limb, and fragment of a limb, affording proof of having been parts of a well adjusted perfect whole, and are fresh evidences of the infinitely varied and inexhaustible contrivance of creative wisdom.*

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* Slightly altered from Buckland.

The relics of various other animals are found in the vast alluvial plains of America; and it is a striking fact, that wherever the bones of gigantic races of peculiar creatures have been found, there, races of similar creatures but of diminutive sizes, still exist. Such are the present sloths, ant-eaters, and armadillo tribes of South America.

Large districts on the surface of the Earth, both in low marshy lands and on the tops of mountains, are covered with moist spongy bogs, called peat moors or morasses. These bogs are only passable in the driest seasons, or when "all nature is locked in frost." (10) They are formed by successive layers or beds of mosses, reeds, rushes, and other plants, that possess the power, when the lower extremities die, of sending forth fresh shoots from the upper portions. The individual plant thus becoming in a manner immortal, and supplying a perpetual fund of decomposing vegetable matter, upon which the new shoots live.

Sir Charles Lyell informs us, that the origin of most peat bogs in the north of Europe, arises from the want of drainage in forests. Trees from the effect of storms, or of natural decay, stop the passage of the waters, upon which mosses and marsh plants spring up, and overwhelm and bury the prostrate trees. In some places peat bogs are shallow, in others they attain to a depth of forty feet. Many ancient forests on the continent are now covered by morasses and fens, whose origin is attributable to the destruction of ancient woods by the Romans.

Skeletons of animals and of human beings, have not unfrequently been discovered in peat bogs, into which they appear to have sunk in a similar manner to that in which the mastodon may have become entombed in the Salt lick of North America. A remarkable instance is on record, of a whole troop of horsemen having been embedded in a bog after the battle of Solway, in 1542, between Henry VIII. and James V. of Scotland. The Scotch army being routed, this unfortunate troop of horse in making a hasty retreat, were said to have plunged into the morass, which instantly closed upon them. This fearful disaster became a traditional story, but was scarcely believed, until about two centuries ago, when a man and horse in complete armour, were discovered by peat diggers who were working on the very spot where the accident is recorded to have happened. The skeletons were both well preserved, and the different parts of the armour were readily distinguished.

Peat bogs in Ireland are numerous, and are said to extend over one-tenth part of the land. The antlers, and other remnants of enormous elks, are frequently found in these bogs; as well as a remarkable substance somewhat resembling spermaceti, termed adipocere, which is said to be animal matter, changed by the qualities of the peat into a white unctuous substance.

Peat holds a middle place between vegetable matter ᐧnd mineral coal, and is cut in large quantities for

With these peat bogs we close our remarks upon the ancient depositions around the globe.

QUESTIONS.

What does the term Alluvium come from? .... (1)
What took place after the Pliocene era? .... (2)
What did these inundations destroy? .... (3)
From whence did the numerous drifts of boulders that cover many parts of Europe seem to come? .... (4)
How are blocks of stone supposed to have been transported?......................... .... (5)
What occasioned ledges or flat terraces on the sides of hills? (6)
In what have specimens of huge ancient elephants been found? ....(7), (8)
What kind of remarkable animal has been preserved in the soil of South America? .... (9
What is the origin of bogs? .... (10)

CHAPTER 24.

CONCLUSION.

We have now arrived at the period in which the crust of the Earth had reached its present depth of eight or ten miles—its hard rocks had been completed, and its Drift deposits accumulated, beneath which lie buried the wild beasts of the Pliocene era.

We have seen that the dry land of the world, with its rocks and its mountains, all bear the indelible stamp of having been little else than the successive beds of seas and of lakes. According to the Psalmist we can say, " He hath founded it upon the seas, and established it upon the floods."—*Ps.* xxiv., 2. The rubble spread over the surface of the Earth teaches us, that after the beds of the ancient seas and lakes had been elevated above the waters, in the forms of Europe, Asia, Africa, America, and New Holland, the whole world, by the fiat of the Almighty, was again submerged or sunk in the Diluvial period nder the waters. The Bible also attests this fact. the second verse of Genesis we are informed, that t before man was created the waters of the deep covered the earth—that it "was without form and void" (of animal life), "and that darkness was upon the face of the deep." For what length of time this state continued is no where recorded, but we read that at length the Spirit of God moved upon the face of the waters; a command went forth, "Let there be light, and there was light." The dry land was again raised up or separated from the waters, and that new creation which is described by Moses[*] was then called into existence.

The four types of animal life, the *Radiated*, *Articulated*, *Molluscous*, and *Vertebrated*, which had prevailed in the olden rocks were retained; but we see that the forms of the different species in these divisions were altered, to suit the present finished state of the world's surface.

Since that period, the Alluvial soils, or loose earthy and vegetable moulds upon which we tread, have been accumulating to great depths. In their superficial deposits, lie thickly strewn the remains of the present races of animals, with the bones of man and his works of art; whilst in the under rocks, amidst the swarming millions of forms belonging to the ancient orders of animals, no clear trace has ever been found of the human family.[†]

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[*] Genesis i.

[†] Human bones have occasionally been met with in deep rocky fissures, but always appear to have fallen in at some opening at the surface, or to have been carried in by streams of water. A human skeleton has been found imbedded in the sandstone of Guadaloupe; but that sandstone is now forming on the sea shore, by the binding together of its sands and pebbles.

The surface of the Earth, during the last six thousand years, appears to have undergone but little change, although partial alterations have taken place, from the constantly elevating and depressing influences of internal movements, from occasional outbursts of volcanic earths, and from salt and fresh-water inundations. The most general and awful of which was the great deluge described in the Bible; yet there is no reason to believe the rocks were overturned at that period—the face of the Earth being simply described as covered with water.

Thus having traced in the rocky layers of the Earth, the wonderful records of Almighty power and wisdom, as written on the stony monuments of the globe, our slight *Geological* sketch is concluded. By the brilliant discoveries of modern Geology the unity of one stupendous design pervading the mind of the First Great Cause, is clearly displayed. "And so far from being opposed to the religion of the Bible, Geology is the only science capable of demonstrating, that a special Providence alike directs the fiery vomits of the volcano, and imparts life to the meanest animal."* It teaches man that there was a starting point—a beginning; it shews him that the regulating hand of Omnipotence has, throughout the immensity of the past, adjusted and maintained the economy of our planet, during a series of turbulent changes and at repeated elevations above, and depressions under the waters, peopling it with successive races of animals, adapted for the changing scenes they were for a brief span destined to animate.

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* Richardson.

To the geological eye the lowest ranges of rocks display many proofs of heat, storm, and violence. They contain rich treasures of mineral ores, but offer no evidences of animated life. In the *Transition* rocks, shells, worms, and sea weeds first appear. Then follow tribes of creatures somewhat like beetles and crabs, plants of wondrous growth, and fishes of forms so wonderful, that no succeeding tribes have attained to the perfections they possessed; on which account the Transition rocks have been termed the Age of Fishes. As the *Secondary* rocks accumulated, reptiles advanced in numbers vast, and of prodiguous sizes. They were not introduced on the stage of life in their lowest forms, but possessed complicated organizations, uniting in themselves qualities of form, since divided between two or three other tribes of animals. These reptiles were the *Master Existences* of the Secondary rocks, and were accompanied by huge frogs and birds, and a profusion of smaller creatures, shells, and corals.

During the formation of the salt and fresh-water rocks of the *Tertiary* series, a vast change took place in animal life. Reptiles diminished in number and in size, but the wild beasts of the field abounded, appearing under a variety of forms, and often in collossal proportions. The mighty beasts of this era, bore for ages the chief sway on Earth; but at length they were swept away as the period approached, in which immortal man, created in the image of his Maker, was to be introduced as the ruling lord of the whole Earth.

Formed to hold communion with his Creator, man by sin soon fell into a state of death and separation from his God. Yet not forsaken by his merciful Creator, he was sent a message of reconciliation, with the promise of a gift of new life, through reliance upon the merits and sufferings of the Son of God. To accomplish this reconciliation, the Maker of the whole Earth took upon himself a body—bone of our bone, and flesh of our flesh, and turned the Earth into a battlefield between the powers of light and darkness. In our flesh he made atonement for sin, overcame death, and rose a conqueror into the highest heavens. And finally, by His word and by His spirit He now calls upon man to look unto Him, and to prepare for a translation into the kingdom of his God and his Father.

Unlike the beasts that perish—man can never be annihilated; but in the latter days every grave shall be opened, the Earth shall give up her dead, and all shall rise; some to honour and some to dishonour. At the sound of the last trumpet, in the twinkling of an eye, the believer in Jesus shall awake in the likeness of his Saviour—shall ascend to the realms of bliss, and ever advancing in holiness d knowledge, be supplanted by no higher race, but oughout the vast ages of eternity shall fill the wide vens with hallelujahs and thanksgiving! But the believer and the impure shall be cast out; the sin polluted Earth be purged by fire, and "the elements melt with fervent heat;" after which, "we, according to His promise, look for new heavens and a new Earth, wherein dwelleth righteousness."*

Thus we are able to perceive by the word of Revelation, that the Divine architect of this globe had two objects to set forth in its creation. First, the manifestation of His creative wisdom; and secondly the formation of a home for man, by whose redemption from sin and death, and preparation for a future throne of glory, is afforded unto principalities and powers in heavenly places, the grandest manifestation of His attributes of power, justice, mercy, and love.

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* 2 Peter iii. 12, 13.

GLOSSARY.

Algæ—Sea weeds.

Alluvium—Crumbled soil, derived from the washing of earths in water.

Alumine—Clay.

Amorphus—A mass devoid of regular form, like a wall of bricks thrown down.

Amygdaloid—Volcanic rocks with holes which are filled with lime, flint or others earths.

Anthracite—Stone coal, or the carbon of the wood uncrystalised, and mixed with clay, &c.

Arinaceous—Sandy.

Argillaceous—Composed of clay.

Articulated — Animals having horny jointed coats and no internal bones.

Augite—A dark green mineral in volcanic rocks.

Basalt—Ancient lava composed chiefly of augite and felspar.

Batrachian—Animals like frogs.

Belemnite—A long dart-shaped fossil, the internal shell of an extinct cuttle fish.

Bitumen—Mineral pitch.

Brachiopoda—Mollusks that fasten themselves by arm-like processes.

Breccia—Pieces of rock settled in a paste of lime, sand, or clay.

Brackish—Water tasting salt.

Boulders—Large masses of rock broken off their native beds.

Calcareous—Composed of lime.

cium—Metallic base of lime.

Carbon—The elementary or chief substance of charcoal. Diamonds are pure carbon.

Carbonate of Lime—Lime and carbonic acid gas mixed.

Carboniferous-Belonging to coal.

Chalcedony—A species of silex, named so from Chalcedon, in Asia, where it abounds.

Chelonia—Animals of the turtle kind.

Chert—Lime mixed with flint.

Cilia—Hair-like vibrating organs.

Cleavage—The peculiar leaf or plate-like structure in slate rocks.

Coal measures—Fields or basins of coal, including their sandstones.

Conformable—Rocks lying upon each other in parallel or flat lines.

Conglomerate—Pieces of rock with angular edges cemented into muddy pastes of lime, sand, or clay; a kind of breccia.

Conifera—Trees bearing cones, like fir trees.

Corn Brash—A coarse shelly limestone of the Oolites.

Crag—Tertiary beds of sand and shells.

Crater—The opening mouth or vent of a volcano.

Cretaceous—Belonging to chalk.

Crinoida, or Lily—A name given to a race of animals that possessed a long pliant stem with a lily-shaped head.

Crustacea—Animals with horny and lime coats, like crabs.

Crystaline — The decided form given to each kind of earth, when its atoms have time given to settle according to a law impressed upon them.

Ctenoid—A fish scale which has its edges jagged like a comb.

Cycadæ—Plants allied to palms and ferns.

Cycloid — Fish scales that are smooth at the edge and often ornamented on the upper surface, such as on the herring and salmon.

Debris—The broken pieces or shivered particles of rocks thrown down.

Delta—Beds of mud and sand settled in the sea at the mouths of rivers.

Detritus—Crumbling particles of rocks made fine.

Diluvium—Deposits formed by water in ages long gone bye.

Dike—Melted lava forced into rents and fissures of stratified rocks. On the rocks crumbling away, these lava streams stand out like walls, and are called dikes.

Dolomite—Lime and magnesia.

Encrinite—Meaning lily; a name given to lily-shaped sea animals mounted on a jointed stalk.

Eocene—The dawn of present things; the early Tertiary strata.

Escarpment—The steepest side of a mountain chain.

Exuvia—Fossil remains of animals.

Fault—A change in the regular extent of strata by being broken into and made to dip down or rise up.

Fauna—The animals of a particular country.

Felspar—A mineral that forms a large portion of granite and volcanic rocks.

Flora—The plants of a country,

Foraminifera—Animalcules having perforated shells.

Formation—A group of rocks supposed to have been made in one geological period.

Fossil—Animal or vegetable remains turned in the ground into stone. From the Latin, *fodio*, to dig out of the Earth.

Ganoids—Fish scales of a long form with angles, composed of either horn or bone, and covered with bright enamel.

Green Sand—The lowest portion of the chalk formation.

Green Stone—An ancient volcanic rock composed of felspar and hornblende.

Grey Wacke—Pieces of rock settled in a paste of lime, sand, or clay, bearing the marks of being hardened by heat.

Gypsum — Lime and sulphuric acid.

Hornblende—A simple mineral of a dark green or black colour.

Hypogene—Rocks formed by fire in the interior of the Earth.

Icebergs—Floating masses of ice.

Iguana—A lizard of the West Indies.

Infusoria—Minute animals found in water mixed with vegetables.

Laminæ—Thin layers of mud, or leaves of dried hardened mud, resting one upon another.

Lava—Melted stony muds poured out of volcanoes under the pressure of our atmosphere.

Lignite—Imperfect coal, carbonised wood.

Littoral—Shallow parts of the sea shore subject to rise and fall of tides.

Mammalia—Animals which give suck to their young.

Marl—A mixture of lime and clay.

Mica—One of the minerals in granite.

Miocene—Middle Tertiary series.

Mollusca—Soft animals, shell fish.

Nodule—A round mass of earth or minerals.

Obsidian—Glassy felspar.

Oolite—Limestone composed of egg-like globules.

Oxide—A combination of oxygen with any metallic substance.

Pachydermata—Thick skinned animal like an elephant.

Placoids—Fishes covered with broad horny plates, irregularly coated with plates of enamel, and often armed with a spike or small eminences like a rough file, as in the shagreen of sharks.

Pliocene—The newest group of the Tertiary series.

Pumice—Volcanic ashes, or light spongy porous lava, made so from being thrown out full of gases that escaped into the air.

Pyrites—Sulphuret of iron.

Quartz—Nearly pure flint or silex.

Radiata—Lowest class of animals, like corals.

Saurians—Reptiles of the lizard order.

Sedimentary—Deposits formed under water.

Septaria—Nodules of clay, having crevices filled with spar.

Shale, or *Schist*—Slaty clay.

Silex—Pure flint, or the quick-silver-looking mineral of silicon, mixed with oxygen gas.

Silt—River mud.

Stratum--A layer of any deposit.

Syenite, or *Sienite*—Granite in which hornblende supplies the place of mica.

Tertiary—Ancient formations, but newer than chalk.

Testacea—Shells.

Trachyte—Lava chiefly composed of felspar.

Trap—Rocks from Trappa stair.

Trilobites—Three-lobed extinct animals.

Tufa—Limy deposits from water.

Unconformable—Strata lying in a different position to those on which they rest.

Univalve—Shells of one piece.

Vertebrated—Animals having a bony flexible spinal column.

Volcano—Fiery opening in the Earth.

Zoology—Study of animals.

Zoophytes—Animal plants, such as corals.

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